New Scientist

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WHY INSECTS ARE DRAWN TO LIGHT

WEEKLY 29 April 2023

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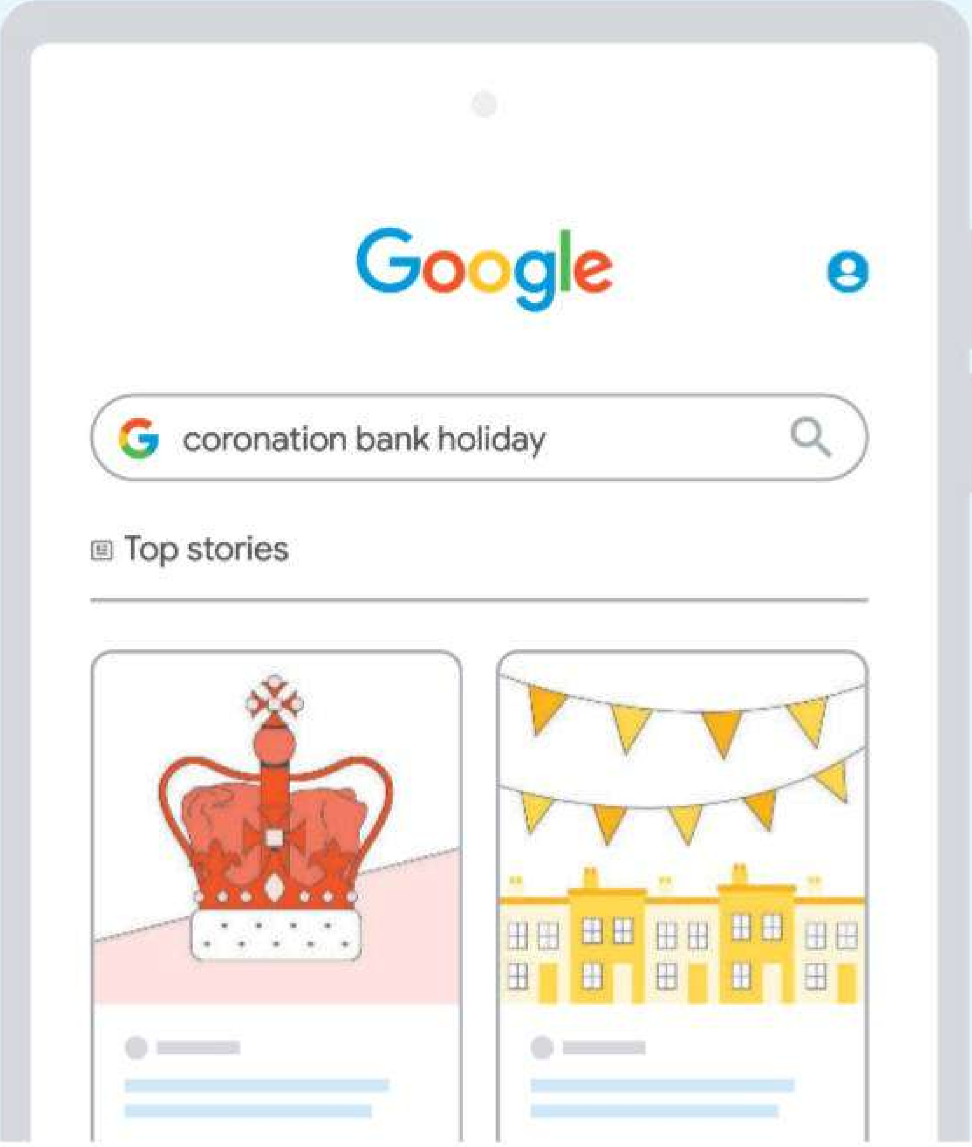

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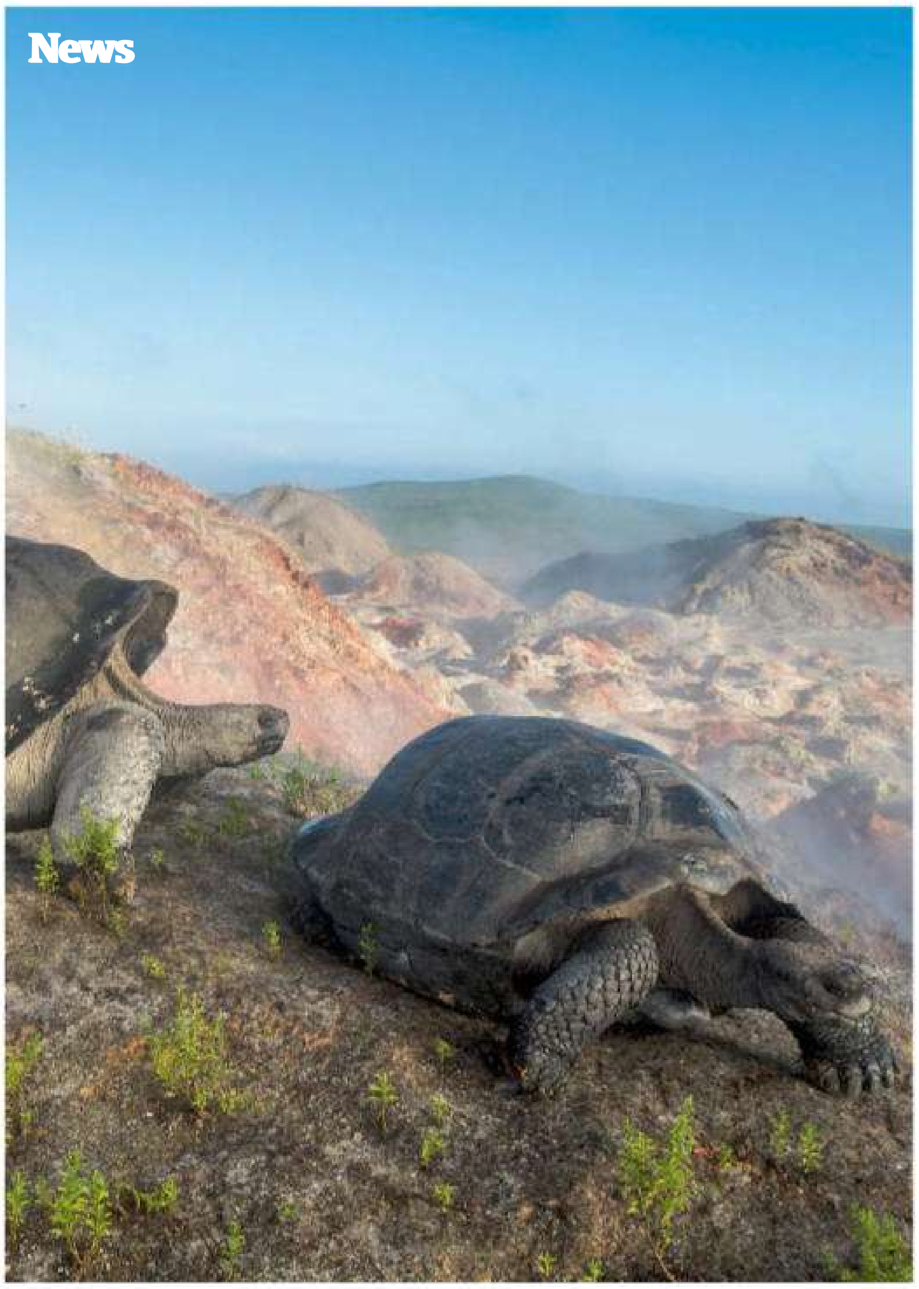

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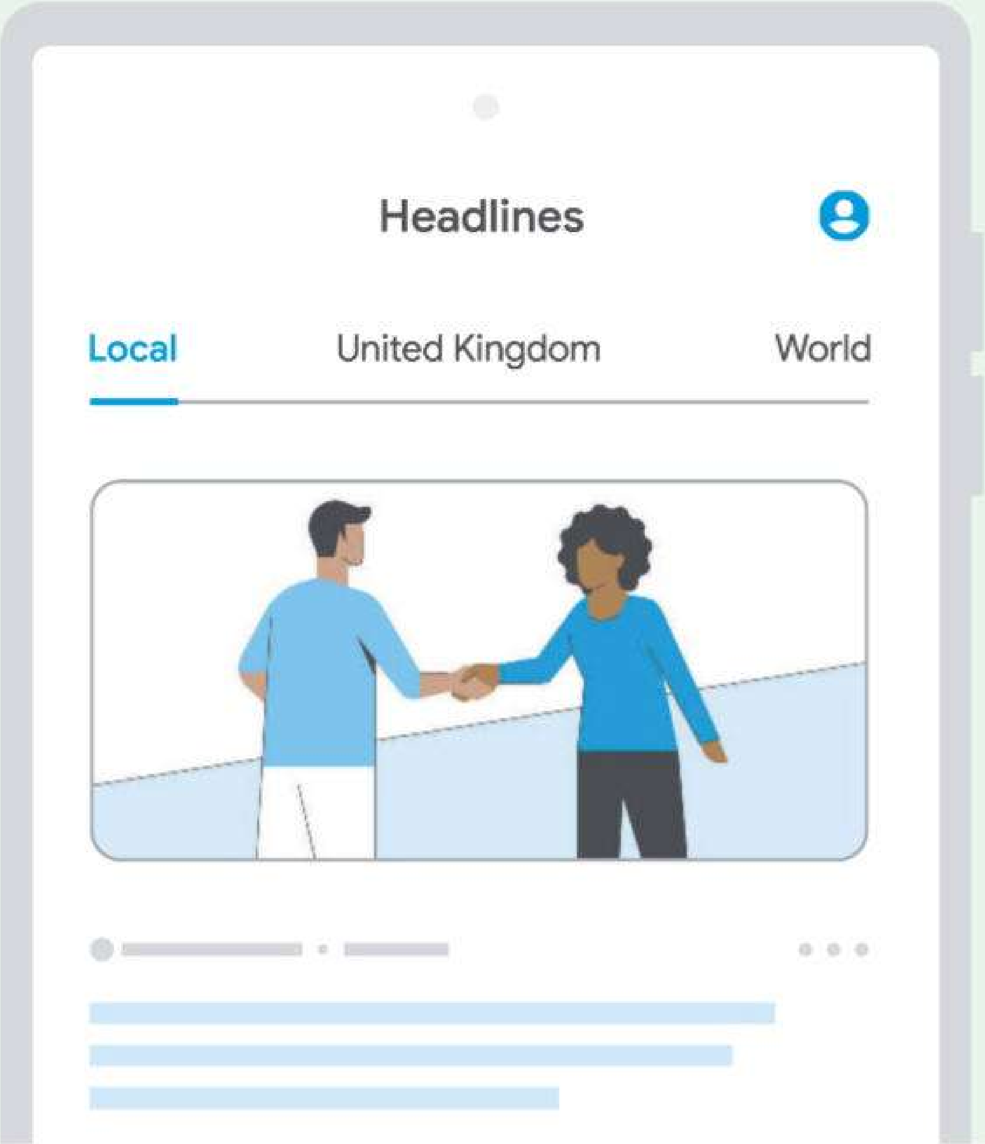

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Elsewhere on New Scientist

Virtual event

Opening the Infrared Treasure Chest with the James Webb Space Telescope

Join Nobel prizewinning astrophysicist John Mather as he discusses how NASA and its partners built the James Webb Space Telescope – and learn about the discoveries made since it began its science operations last year. Watch online at 6pm BST/1pm EDT on 17 May. Early bird tickets are £14.

newscientist.com/events

Tour

Human Origins: Prehistoric south-west England

Explore the ancient heritage of Wiltshire and Dorset. This gentle walking tour visits the monuments of Stonehenge and Avebury, plus the settlement of Old Sarum. Led by accredited guides and joined by *New Scientist* editor-in-chief Emily Wilson, the trip begins on 4 September. Tickets are £1595.

newscientist.com/tours

Podcast

Weekly

We finally know why insects gather around artificial lights, and it has nothing to do with the moon: the team discusses the explanation. There is also news of a radical way to geoengineer the oceans. Plus, in a bonus episode, podcast editor Rowan Hooper chats to Daniel Goldhaber, Ariela Barer and Daniel Garber about their new film *How to Blow Up a Pipeline*.

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NASA, ESA, CSA, AND STSCI

Space nursery New stars are born in the Carina nebula

OLGA MILTSOVA/SHUTTERSTOCK

Dietary advice There are many different ways to lose weight

Video

Off-road robotic drivers

On our YouTube channel this week there is footage from the Mojave desert, where the US military DARPA programme is testing robotic all-terrain vehicles. The engineers hope that, by trialling the vehicles on rough terrain, they will speed up the development of autonomous vehicles that can navigate challenging environments as quickly as human drivers.

youtube.com/newscientist

Newsletter

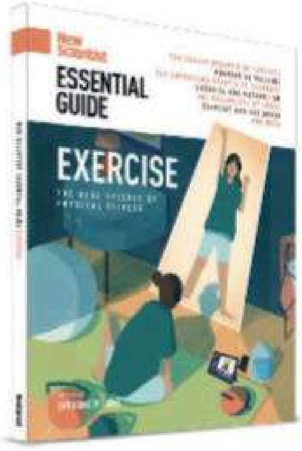
Health Check

Recent news suggests that people with type 2 diabetes can go into remission by losing weight, and there are many weight loss strategies to choose from, says health reporter Clare Wilson. They include both low-calorie and low-carbohydrate diets – and even new weight loss drugs.

newscientist.com/health-check

Podcast

> **"Is the folklore idea that lights attract insects wrong?"**



Essential guide

Exercise is the best medicine. It keeps body and mind in prime condition and adds years to our lives. But why do so few of us get enough? This *New Scientist Essential Guide* offers some clues. Available to download in the *New Scientist* app or to purchase in print from our shop.

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How to eat healthily

Evidence – not stigma – should be at the heart of efforts to tackle processed food

THINK of unhealthy foods and you might picture takeaways, fried foods or sweets – products high in fat or sugar. But a new idea says we should shift our focus away from a food's nutrient content to how and where it is made.

Anything cooked from scratch in your own home is allowed, while food made in a factory, which is now classed as "ultra-processed" thanks to artificial ingredients like additives or high-fructose corn syrup, is frowned upon.

Consider a pre-packaged loaf of brown bread. Usually seen as wholesome fare, its additives put it in the ultra-processed camp. Most breakfast cereals would join it, as would anything containing a preservative or a sweetener – which might include seemingly healthy things such as low-fat yogurt or shop-bought hummus.

According to campaigners like Chris van Tulleken (see page 46), the high palatability of ultra-processed foods and the fact they don't leave people feeling full explain the global obesity epidemic, rather than how much fat or sugar we eat.

> "It is unreasonable to expect families to start cooking all their meals from scratch"

While van Tulleken and others are vocal about their cause, we shouldn't be too quick to tear up current healthy eating guidelines, as the supporting research is still sparse. But if it is borne out by further studies, what can we do about it? It is a real conundrum.

Ultra-processed food is an integral part of the food system in most high-income countries, and it is often the cheapest food. It is unrealistic to expect families simply to start cooking all their meals from scratch, and many people don't have the time or the money to do so.

Instead, possible steps include changing food labelling and marketing rules to make it clearer that food is highly processed – which is already done in some South American countries – without raising stigma.

Above all, any measures should be road-tested in pilot studies before being widely rolled out. If the latest idea is right, current healthy eating guidelines have made several missteps. We don't want to get it wrong again. ▮

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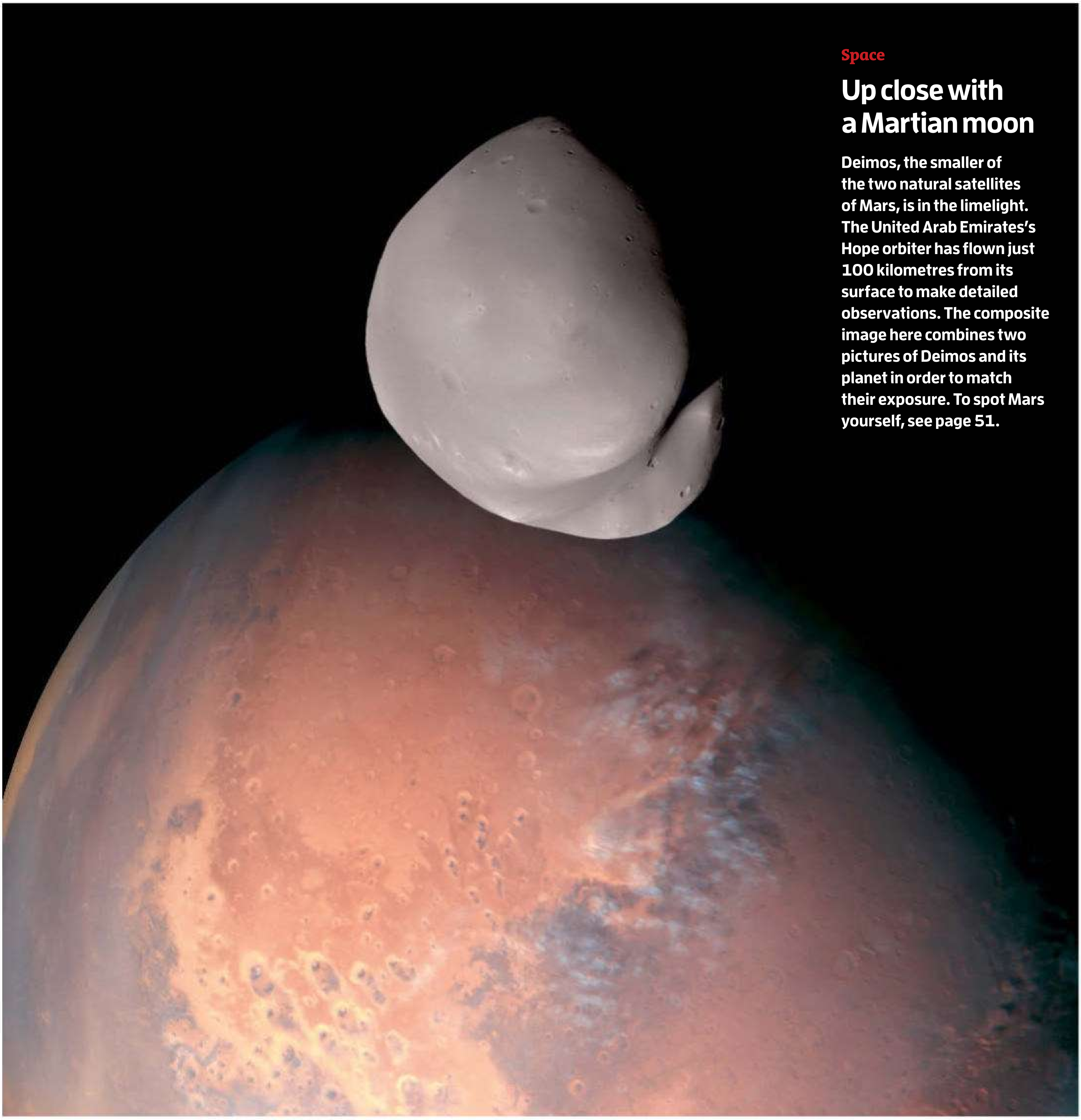


Space

Up close with a Martian moon

Deimos, the smaller of the two natural satellites of Mars, is in the limelight. The United Arab Emirates's Hope orbiter has flown just 100 kilometres from its surface to make detailed observations. The composite image here combines two pictures of Deimos and its planet in order to match their exposure. To spot Mars yourself, see page 51.

EMIRATES MARS MISSION

Animal behaviour

Why insects gather at lights

Artificial light doesn't actually entice insects towards it, but instead interferes with the systems they use to orientate their body when flying, finds **Michael Le Page**

WE FINALLY have a good explanation for why insects flock around artificial lights, and it isn't because they are attracted to them.

"Our results suggest artificial lights may only trap passing insects rather than attract them directly from farther away," write Samuel Fabian at Imperial College London and his colleagues in a research paper.

Until now, the leading scientific hypothesis has been that insects use the moon's light to navigate at night and mistake artificial lights for the moon. But this celestial navigation idea doesn't explain why insects that only fly during the day also gather around lights. It also predicts that insects will fly in a spiral towards lights, which isn't what they do.

To find out what really happens, Fabian and his colleagues filmed insects in the wild around lights using a high-speed camera. They also used motion capture in an enclosure to trace the precise movements of other insects, including dragonflies and moths.

Loop-the-loops

This revealed three notable behaviours. First, when insects fly above lights, they often invert themselves and try to fly upside down, causing them to plummet.

Second, just after insects pass under a light, they start doing a loop-the-loop. As their climb angle becomes too steep, they stall and start to fall.

Third, when insects approach a light from the side, they may circle or "orbit" the light.

The videos show that insects fly at right angles to lights rather than directly at them. However, because inversions and stalls sometimes result in insects falling on lights, it can appear to the naked eye as though they are deliberately flying at the lights.

ASHLEY COOPER/ALAMY

Large numbers of insects often swarm around artificial lights

What is common to all three behaviours is that the insects are keeping their backs to the light, say Fabian and his colleagues, so they are proposing that lights trigger what is known as the dorsal light response (bioRxiv, doi.org/j67b).

This reflex, which exists in some fish as well as many insects, is a shortcut for animals to work out which way is up and keep their bodies upright. It relies on the fact that, even at night, the brightest hemisphere in the visual field is usually up.

There are circumstances in which the dorsal light response might lead an insect awry, such as at dawn or dusk. But insects use a combination of methods to tell which way is up, and different species rely on the dorsal light response to different degrees. Oleander hawkmoths and fruit flies, for example, didn't invert or orbit near lights, the researchers found.

However, in many species, the dorsal light response appears hard-wired. And in a simple computer simulation, the researchers found that virtual insects given a dorsal light response also inverted, stalled and orbited, just like they did in the videos.

> "This provides a credible answer to a question that has been around since at least the Roman era"

The dorsal light response has been known about for decades, but hasn't been proposed as an explanation for why lights trap insects until now.

"I think it is a totally plausible idea that the dorsal light response induces this rotational behaviour that traps insects around lights at night," says Roman Goulard at Lund University in Sweden, who showed in 2018 that shining lights upwards from below made hoverflies more likely to crash.

The idea also seems a better fit than other hypotheses for why insects gather around lights. Besides celestial navigation, one is that insects fly towards light as an escape mechanism, because in enclosed spaces light sources show where gaps are. But the fact that insects rarely fly straight towards lights rules this out, say Fabian and his colleagues.

Not about heat

Another idea is that insects are blinded by bright lights, but this doesn't explain behaviours such as orbiting. Many studies have shown that insects aren't attracted to the heat of lights.

The dorsal light response provides a credible answer to a question that has been around since at least the Roman era, says Roy van Grunsven at Dutch Butterfly Conservation in the Netherlands, who has studied the effect of artificial lights on insects. "I've never been convinced by the other theories."

As Fabian and his colleagues studied only what happens within a couple of metres of a light, they can't completely rule out a longer-distance attraction to light. However, they don't think it is likely.

They hope their research will help find ways to minimise the damaging effects of artificial lighting on insects, which might be contributing to their global decline.

"Reducing bright, unshielded, and upward facing lights will mitigate the impact on flying insects at night," write the researchers. ▮

Health

Stress can biologically age you, but the effect isn't permanent

Alice Klein

WE BECOME biologically older when our bodies are under stress, but younger again when we recover, according to a study that analysed people's DNA when they had emergency hip surgery, had severe covid-19 or were pregnant.

"This recovery suggests we have the machinery to be able to rewind the clock back at least a little bit," says James White at Duke University in North Carolina, who co-led the study with Vadim Gladyshev at Harvard University.

We normally measure age by the number of birthdays – so-called chronological age. But people can be biologically older or younger than their chronological age depending on factors such as whether they smoke. We can measure this with "epigenetic clocks" that analyse patterns of markers on DNA called methyl groups that correlate with age.

White, Gladyshev and their colleagues used these clocks to assess the impact of three types of stressful event on biological age. They analysed DNA from blood samples that were collected at multiple points in time from participants in previous studies.

In the first analysis, the team found that the biological age of nine people with an average age of 81 rapidly rose after emergency surgery to repair a broken hip, but returned to pre-surgery levels over the following week.

Next, the team measured the biological age of 29 people with an average age of 60 while they were hospitalised with covid-19 and after they were discharged. The biological age of female participants fell after discharge, but that of male participants didn't, possibly because men take longer on average to fully recover from the disease, says White.

Finally, the team compiled data from four studies that included more than 200 women who were pregnant, which is known to put stress on the body. Their biological age increased over the course of the pregnancy, but, by six weeks after delivery, it had returned to below the levels seen in early pregnancy. No transgender men or non-binary people were included in this part of the study.

ALEX SEGRE/ALAMY

You are only as old as you feel, but stress doesn't help

The researchers also used epigenetic clocks to measure the biological age of mice before, during and after pregnancy and found the same pattern (*Cell Metabolism*, doi.org/gr5z88).

The idea that biological ageing speeds up during stressful events but reverses afterwards is consistent with a previous study that found that people's grey hairs sometimes regain their original colour after they recover from psychologically stressful events.

However, Luigi Fontana at the University of Sydney in Australia says that even though there may be short-term fluctuations in biological age, the trend is still to become older. "Your grey hair may regain some colour, but it isn't going to revert to the hair you had as a 10-year-old," he says.

Nevertheless, now we know that biological ageing can at least reverse slightly, it raises the possibility of being able to develop therapeutics to drive this reversal further, says White. ▮

Technology

Wood transistor could let us embed electronics in trees

AN ELECTRICAL switch made from conductive wood could become a building block for future electronics.

"There is an emerging research field called electronic plants, where scientists look at different ways to send signals inside plants or to incorporate functionality such as sensors in plants, even in living plants," says Isak Engquist at Linköping University in Sweden.

Engquist and his colleagues have developed a wooden version of a transistor – a component that can boost electric currents or act as a switch for electric signals.

At 3 centimetres long, it is much larger than silicon transistors, which can squeeze in their billions onto a fingernail-sized computer chip. It is also slower, taking seconds to switch on and off, while silicon ones can do it billions of times in a second.

But the wood transistors could be sustainable and biocompatible for applications in agriculture or forestry, such as monitoring plants' resistance to environmental stress and climate change.

VAN CHINH TRAN

An electronic transistor made from balsa wood

To create the wood transistor, Engquist and his colleagues used heat and chemicals to remove the compound lignin from bits of balsa wood. That freed up space in the network of tubes, called lumina, that transport water within wood.

They then immersed the wood in a liquid containing a conductive polymer, allowing the polymer to soak into the wood and coat the lumina. This made it capable of interacting with electrolytes – chemicals that conduct electricity when dissolved in water – as the foundation for constructing a wood transistor (*PNAS*, doi.org/j7d7).

The researchers measured the wood transistor's operations during multiple switching test runs.

The work represents an exciting possibility for utilising wood as a scaffold to incorporate electrical materials into devices, says Tian Li at Purdue University in Indiana. ▮

Jeremy Hsu

Health

Lack of neuron 'pruning' behind many brain-related conditions

Clare Wilson

SEVERAL disparate conditions, such as depression, phobias and attention deficit hyperactivity disorder (ADHD), may have the same underlying cause: a delay in "pruning", a process in which unneeded connections between brain cells disappear.

The finding comes from one of the largest brain-scanning studies done in adolescents and has been confirmed in several other data sets, including people of other ages.

"We've been able to show that these different [conditions] are all related to a single underlying neurobiological factor," says Barbara Sahakian at the University of Cambridge.

The results lend weight to a controversial recent idea in neuroscience that many disparate conditions share a common cause – a concept known as the p factor.

Until now, this was mainly based on the fact that many people have more than one such condition or may be diagnosed with different conditions during their lives, as well as DNA studies finding that the same set of gene variants predispose people to multiple conditions.

Now, Sahakian and her colleagues are proposing a neurobiological basis for the p factor, which they call the "neuropsychopathological (NP) factor".

The researchers did their first analysis using an existing set of brain scanning images for nearly 2000 teenagers assessed at 14, where there was also information about potentially related symptoms they had.

Participants or their parents completed questionnaires to produce scores for symptoms of mental health conditions, such as depression, anxiety, eating disorders and phobias. They were also scored for ADHD and assessed for autism traits.

MEHAU KULYK/SCIENCE PHOTO LIBRARY

Unwanted links between neurons are removed as we grow up

People who had the highest scores for these conditions, indicating stronger symptoms, were more likely to have greater density of tissue in the prefrontal cortex, an outer region of the brain at the front of the head. This, say the researchers, indicates less pruning in their brains.

Pruning is a mysterious process that starts in young childhood, although it increases dramatically in adolescence. It is thought to happen because connections between brain cells – known as synapses – that aren't used very much are lost. "As you're learning and your brain is getting more efficient, you get rid of the extra synapses you don't want," says Sahakian.

2000

The number of 14-year-olds whose brain scans were studied

It wasn't possible to quantify the pruning difference or the difference in tissue density in this study, nor is it known whether those who had a greater density of tissue in the prefrontal cortex at this stage catch up with the rest of the population later, at least to some extent, says Sahakian.

The finding was confirmed in four other sets of brain scanning data, including a second collection of brain scans and symptom scores for nearly 2000 adolescents, and two studies that included people in their 20s (*Nature Medicine*, doi.org/j7fg). This indicates that the lack of brain pruning correlates with brain function in adulthood too, say the researchers.

A lack of pruning has previously been proposed as a cause of schizophrenia, ADHD and autism, but not other conditions.

Robert Plomin at King's College London, who has been involved in genetic studies that support the idea of a p factor, says the new proposed explanation is plausible as a contributor, but may not be the whole story. "You are looking for something that's a general mechanism," he says. ■

Space exploration

Martian base on Earth set to host first 'astronauts'

David L. Chandler

FOUR people will soon stay for one week in what may be the most realistic Martian base on Earth.

The Space Analog for the Moon and Mars (SAM) base has been built on the grounds of Biosphere 2, an ambitious experiment in controlled ecology built in Arizona from 1987.

Unlike other numerous Mars base analogues, SAM will be pressurised and hermetically sealed, just as a real lunar or Mars base would be. The "astronauts" in SAM will have to wear pressurised spacesuits and pass through airlocks every time they go "outside". The outdoor portion is a fully enclosed but not pressurised yard, with rocks and soil similar to those on Mars, and will soon also have a harness system to simulate Martian gravity.

SAM will repurpose the Biosphere 2 Test Module, an almost 50-square-metre hermetically sealed greenhouse. It is intended to provide some of the food supply, as well as a key part of the waste and water recycling system, plus oxygen production and carbon dioxide removal systems. "As the plants mature in the hydroponic systems, there'll be less and less reliance on those mechanical blowers and chemical agents that remove CO_2 from the air," says Kai Staats, SAM's director of research. While initially dependent on resources imported from outside, SAM will transition to a more self-sufficient system for producing food while recycling air and water.

Converted shipping containers hold a lab and workshop area, as well as the living quarters, with a kitchen, sleeping quarters and a common area. The first crew of four, who will enter SAM on 27 April for a one-week stay, include a doctor, a photographer, an aerospace engineer and a communications specialist who is blind and will test the accessibility of the enclosure's monitoring systems. ■

Astrophysics

Evidence is growing for the axion

An overlooked candidate for dark matter may be bending light from distant galaxies

Leah Crane

LIGHT warped by galaxies may be better explained by ultralight dark matter particles called axions, rather than weakly interacting massive particles (WIMPs), which have long been the leading candidate for dark matter.

Researchers are fairly sure that dark matter exists because of its gravitational effects, but efforts to detect any dark matter particle directly have failed. Amruth Alfred at the University of Hong Kong and his colleagues took an indirect look at dark matter by examining an effect called gravitational lensing, in which light from a distant object is warped and magnified by the pull of a relatively nearby galaxy, creating several images of the background object around the nearby galaxy in what is known as an Einstein ring.

NASA/ESA/STSCI

A pair of galaxies bend the light from a distant quasar into an Einstein ring

Galaxies are expected to be surrounded by haloes of dark matter, which should affect how the light is stretched. Axions are many orders of magnitude less massive than WIMPs – while WIMPs behave like standard particles, axions are so light that quantum effects should make them behave more like waves.

So, if a foreground galaxy has an axion halo, it should affect images of the lensed background galaxies. "If you have a pool with waves in it, and you put a stone in it, you are able to see the oscillations in the wave when you look at the stone," says Razieh Emami at the Harvard-Smithsonian Center for Astrophysics in Massachusetts. "In these observations, those wave structures would be directly translated to the position of the lensed images and their brightness."

There are anomalies between the patterns seen in gravitational lensing and WIMP models, but the researchers found that when these were switched out for axion models, the anomalies went away. They also tested the models on a real lensing system and found that the axion model fit much better (*Nature Astronomy*, doi.org/j69f).

"The observations from gravitational lensing do tilt the scale from heavier particles towards lighter ones," says Emami. "So far, there are no other explanations for this phenomenon." This is good news for axions, which have been overshadowed by WIMPs as dark matter candidates for decades.

"I don't think this counts as proof that ultralight axions exist, but it's a compelling result," says Chanda Prescod-Weinstein at the University of New Hampshire. "It provides further evidence that axions as a class of dark matter candidates are compelling."

Immense effort has gone into detecting WIMPs with no luck, so this is part of a renaissance for axions and other dark matter candidates that haven't been as explored. "Axions represent one of the simplest extensions to the standard model of particle physics, and a large portion of their plausible search space has not been explored yet," says Jae Sub Hong at the Harvard-Smithsonian Center for Astrophysics. ▮

> "Axions represent one of the simplest extensions to the standard model of particle physics"

Animal behaviour

Even dead wolves can send boars into a fright

WILD boars are scared of wolves – even dead ones. The carcasses of these apex predators seem to be able to produce a fright that other dead animals don't.

Prey species alter their behaviour based on the predators in their environment, carefully navigating their world to reduce the risk of being eaten. Dead animals can also signal that a predator could be nearby, so some prey animals avoid carcasses. But little is known about how prey animals regard carcasses of predators, and if they could be mistaken for a live threat.

ERIK MANDRE/SHUTTERSTOCK

Boars that encounter dead predators go into a fight-or-flight response

Daniel Redondo-Gómez at the University of Grenada in Spain and his colleagues have now tested this in the Susa valley in the Italian Alps. They placed the carcasses of 10 road-killed wolves (*Canis lupus*) and nine red foxes (*Vulpes vulpes*) in the forests, monitoring them with motion-activated video cameras.

Twenty-six wild boars (*Sus scrofa*) ended up approaching the dead wolves. In nearly a quarter of these encounters, the boars went into an abrupt fight-or-flight response, fleeing or ramming and biting the wolf carcass. But in 14 encounters with the red foxes – which very rarely prey on boars – the pigs had no such fearful reaction (*Ecology and Evolution*, doi.org/j69n). The findings may mean that the "ecology of fear", where predators influence their ecosystem by changing the behaviour of their prey, can persist into death. Carrion may have a bigger role shaping prey species' lives than previously thought.

"That prey recognise their predators even when [those predators] are no longer lethal points to how powerful fear can be," says Liana Zanette at Western University in Canada. ▮

Jake Buehler

Analysis History of science

Was Rosalind Franklin really a victim of scientific theft?

New documents add to the evidence that the popular story of the discovery of DNA's structure is misleading, says **Michael Le Page**

ROSALIND FRANKLIN should be seen as an equal contributor to solving the structure of DNA, not as a victim of theft, a pair of academics argue in an article to mark the 70th anniversary of Francis Crick and James Watson's paper on the structure of DNA. They say an overlooked letter and a draft magazine article add to the evidence that this widely held view of Franklin's role is wrong.

"It deprives her of her agency," says Matthew Cobb at the University of Manchester, UK. "That's not right."

According to many accounts, Franklin, a chemist at King's College London, did all the hard work to elucidate DNA's structure, but Crick and Watson at the University of Cambridge got hold of a key X-ray image she took – Photograph 51 – by nefarious means, allowing them to publish the solution before her. This idea derives from Watson's 1968 book *The Double Helix*, but it isn't true, says Cobb. Watson used Photo 51 as a dramatic device.

All the image revealed is that DNA is helical, which was already known. What's more, the image was taken by Franklin's graduate student Raymond Gosling, who shared it with Maurice Wilkins, the assistant director of the biophysics lab, with her knowledge. Wilkins then showed it to Watson.

AGEFOTOSTOCK/ALAMY

Rosalind Franklin played a key part in the discovery of DNA's structure

More important to the discovery than Photo 51 was a Medical Research Council (MRC) report that included a page from Franklin on her work. This was given to Crick by his supervisor, Max Perutz. The data in this MRC report didn't reveal the structure to Crick and Watson, but was key to confirming their model, says Cobb.

Cobb and Nathaniel Comfort, a historian of medicine at Johns Hopkins University in Baltimore, Maryland, have found a previously overlooked 1953 letter to Crick by a researcher called Pauline Cowan. It invites Crick to a talk by Franklin and Gosling, but says that, since Perutz already knows more than might be in the lecture, Franklin and Gosling think it might not be worthwhile for Crick to attend. The letter shows that Franklin knew Perutz was sharing her findings with Crick and seemed fine with it (*Nature*, DOI: 10.1038/d41586-023-01313-5).

"One of the reasons why they are so relaxed about this is that DNA was not the big deal it is now," says Cobb. It only later became clear how important it is.

Cobb and Comfort have also found a 1953 draft article for *Time* magazine by Joan Bruce that never appeared in print. Bruce portrays a collaborative effort. She writes that, although Wilkins and Franklin worked independently from Crick and Watson, "they linked up, confirming each other's work from time to time, or wrestling over a common problem". It isn't clear whose version of the story this is, but the fact that Bruce sent the draft to Franklin for checking suggests that Franklin had talked or corresponded with Bruce.

Indeed, there is no evidence that Franklin herself felt hard done by. In June 1953, she exhibited a model of DNA at the Royal Society in London, presenting the structure as a joint effort.

Franklin also became friends with Crick and his wife, spending time with them while ill with the cancer that killed her in 1958. Between 1953 and her death, she did groundbreaking work on viral structure that, by itself, might well have won her a Nobel prize had she lived.

> **"The popular view of Rosalind Franklin's role deprives her of her agency. That's not right"**

The letter and draft article strengthen the case for an alternative version of history that others have already put forward.

In 2003, for instance, Franklin's biographer Brenda Maddox wrote in *Nature* that "the legend of Franklin, the wronged heroine" has "overshadowed her intellectual strength and independence both as a scientist and as an individual". At the very least, Franklin's story is more complex than the myth. ■

Neuroscience

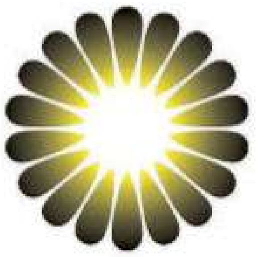
Brightness illusion fools rats in same way as humans

AN OPTICAL illusion that plays with our perception of brightness also seems to work on rats, suggesting that the connection between perception and pupil size evolved early on in mammals.

The Asahi illusion (pictured right) is made up of a series of petal-like shapes surrounding a white centre. The petals are yellow close to the centre, transitioning to black at the edges, and this gradient, combined with the shape of the petals, makes it seem as if the white centre is brighter than it actually is.

Most people are tricked by this illusion, says Nelson Totah at the University of Helsinki in Finland, to the extent that our pupils constrict as our brains believe we are looking at something very bright. This reaction is known as the pupillary reflex and it helps protect our retinas from bright light.

Totah and his colleagues showed 14 rats the Asahi illusion while tracking their pupils and found that they constrict just like in humans (*Cerebral Cortex*, doi.org/j68n).



LAENG ET AL.

The centre of the Asahi illusion appears brighter than it really is

This suggests the rats' mental processes can affect pupil size, though it is important to note that we don't know if the rat perceives the image as brighter than it actually is, in the same way humans do, says Totah.

It is reasonable to assume that the brain mechanisms triggered by this illusion in humans are also present in rats, says Totah, which suggests that the brain's ability to control the pupillary reflex occurred far earlier in mammalian evolution than previously thought. "But I have no idea why this ability evolved," he says. ■

Jason Arunn Murugesu

Anatomy

Women's small intestines are longer than men's

Christa Lesté-Lasserre

SMALL intestines are on average 30 centimetres longer in women than in men, with this added length probably helping them to better absorb nutrients if needed for pregnancy and breastfeeding.

"The small intestine is all about absorption, absorption, absorption," says Amanda Hale at North Carolina State University. "It's where you get the vast majority of your nutrients."

With there being little information on the anatomical variations that can exist between different people's organs, Hale and her colleagues measured the digestive organs of 21 female and 24 male human adult cadavers that had been donated to Duke University, North Carolina. They found that, on average, the male cadavers' small intestines were slightly over 4 metres in length, while those of the female cadavers were 30 centimetres longer (*PeerJ*, doi.org/j686).

"If [women's small intestines] are longer and there's more surface area, that means they can pull more from everything that they eat," says Hale. "That might be related to reproduction, and it most likely is."

However, this anatomical difference probably doesn't explain why some gastrointestinal conditions are more common in one sex than the other. Sex-related differences in our immune systems and genetics probably play a role here, says team member Erin McKenney, also at North Carolina State University.

Overall, the results point to taking people's anatomy into consideration when diagnosing and treating them, the researchers write in their paper.

The study was made up of a relatively small number of subjects, but the researchers say this could strengthen their findings. "It is worth noting here that we found such variation even though we measured just 45 human cadavers," they write. ▮

Climate change

Geoengineering the seas could be catastrophic for marine life

Madeleine Cuff

EFFORTS to boost the ocean's carbon-storing capacity by making seawater more alkaline could disrupt the marine food web, researchers have warned.

Ocean alkalinity enhancement is a proposed method of removing excess carbon dioxide from the atmosphere. It involves adding alkaline substances, such as basalt or calcium oxide, to ocean water to increase its pH. This helps to convert dissolved CO_2 in seawater into carbonates and bicarbonates, unlocking capacity for the oceans to draw down further CO_2 from the atmosphere.

The oceans already hold around 38,000 billion tonnes of carbon. In theory, ocean alkalinisation could remove many billions of tonnes more CO_2 from the atmosphere, helping to limit the impacts of climate change. But releasing vast quantities of alkaline substances into the ocean could have catastrophic consequences for the marine food web.

Marine snow

Chris Reinhard at the Georgia Institute of Technology in Atlanta and his colleagues investigated how the release of alkaline minerals would affect the cycling of carbon in the ocean. Using computer models, they assessed the impact of alkaline mineral release on "marine snow", the particles of organic matter that drift down from upper layers to the deep ocean.

"This marine snow is really central to the ecological and biological function of the ocean," says Reinhard. "If we take minerals and we dump them into the ocean, they're going to intersect with this background particle field in ways that may or may not be predictable, and may or may not be beneficial. ”

The study also modelled how effective alkaline minerals would be at boosting carbon absorption in the oceans. The research yielded some worrying findings. Naturally occurring minerals such as basalt and olivine were found to be ineffective at boosting ocean carbon absorption, because they don't dissolve well in ocean water. They may also seriously disrupt the composition of marine snow, reducing the availability of organic particles that zooplankton and other animals rely on for sustenance (*Environmental Research Letters*, doi.org/j69k).

"If you have to search 30 times as hard to find the same amount of organic matter to fuel your metabolism, you are changing the energetics of the entire food web," says Reinhard. "In some cases, you're really wreaking havoc on the background particle field."

This could have serious ramifications across the marine food web, even affecting the number of fish in the ocean, warns Reinhard.

> **"Ocean alkalinisation could have serious ramifications across the marine food web"**

Christopher Pearce at the National Oceanography Centre in Southampton, UK, says the study raises some interesting questions, but more research is needed to see if the findings apply in real-world tests. Shallow coastal waters may respond differently to alkalinisation compared with the open-ocean settings the study modelled, he says. ▮

Zooplankton may be affected by adding alkalis to seawater

TONAQUATIC/ISTOCKPHOTO/GETTY IMAGES

Zoology

Confusion over the number of Galapagos giant tortoise species

Carissa Wong

FOTOGRIN/SHUTTERSTOCK

Iconic giant tortoises roam the Galapagos Islands

HOW many species of Galapagos giant tortoise are there? No one can agree, but the outcome may influence how we conserve these endangered animals.

Researchers have defined 16 populations of giant tortoises (*Chelonoidis* spp.) in the Galapagos Islands based on shell shape, behaviour and genetics. Three are now extinct due to hunting, habitat loss and the introduction of species that compete for their food.

Whether the remaining 13 tortoise populations should be classed as subspecies or distinct species has been a matter of debate for decades, but now it seems to be coming to a head.

"It doesn't matter to the tortoises what we call them, right?" says Evelyn Jensen at Newcastle University in the UK. "But how we label the tortoises can have implications for conservation."

From 2012, the International Union for Conservation of Nature (IUCN) recognised seven named living species and one extra "indeterminate" grouping, based on genetic studies. But in 2021, the IUCN's Turtle Taxonomy Working Group decided that all the populations were part of just one species, following a study published the same year.

The 2021 study looked at 15 tortoises in total from the 13 populations and found that differences in the DNA within mitochondria – which produce energy inside cells – between some members of different Galapagos giant tortoise populations are smaller than differences seen between members of other tortoise species. This suggested the Galapagos giant tortoises are one species, says Anders Rhodin, part of the Turtle Taxonomy Working Group.

The 2021 study "really boils down to them making the point that Galapagos populations are younger than other species", says Jensen. "But there is no rule about how old a lineage needs to be to be called a species."

Jensen and her colleagues want the 2021 IUCN decision reversed. They have now analysed the genomes of 38 tortoises from the 13 living groups. The team used a computational model to compare 50 regions – each 1000 DNA letters, or base pairs, long – that were randomly located across the genomes.

13

The number of populations of Galapagos giant tortoises

The method has distinguished species of mammals, birds and frogs, but hasn't been applied to these tortoises before, says team member Stephen Gaughran at Princeton University.

Jensen and her colleagues conclude that there are at least five species of the giant tortoises and potentially as many as 13 (bioRxiv, doi.org/j6v5).

The single species decision hasn't yet been reflected in the IUCN Red List of Threatened Species, says Jensen, and she hopes it won't be. Lumping species together could cut the financial support endangered populations get, she says.

Wacho Tapia at the Galápagos Conservancy thinks similarly. "If, for example, the Galapagos National Park asks the Ecuadorian government to create a breeding centre for a subspecies, the possibility to get money is very low, but if you ask for money to conserve a species, normally the government takes it more seriously," he says.

Peter Paul van Dijk of the Turtle Taxonomy Working Group doesn't think grouping tortoise lineages will reduce funding. "The Galapagos Islands are such a unique location that a species or subspecies status is really not particularly relevant for people who donate to conservation efforts," he says. ▮

Botany

Carnivorous plants use a sneaky trick for luring different bugs

Sofia Quaglia

SOME carnivorous plants change their scent to attract different types of prey, mimicking flowers in their luring techniques and maybe even regulating their digestion.

Trumpet pitcher plants, or *Sarracenia*, get their nickname from their appearance: their leaves have evolved into the shape of pitcher-like cavities into which insects trip, falling deep into a corrosive, digestive liquid they can't escape.

Laurence Gaume at Montpellier University in France and her colleagues have now found that scent is an important determiner of the kinds of prey these plants capture – and they may be able to fine-tune it to their liking.

The researchers analysed the molecular makeup of scents emitted by 16 different plants from four species of *Sarracenia* and matched that up with the partially digested creatures found in the plants' pitchers. They found that, although pitchers are "generalists" trying to attract a wide range of prey, slightly different perfume recipes correlated with different catches of the day.

"These findings suggest that these carnivorous plants are not simple passive plants with random captures and that they can target their prey," says Gaume.

Species that emitted more chemicals usually found in the scents of fruit and flowers, like monoterpenes and benzenoids, attracted more pollinating insects, while those emitting scents with fatty acids were more alluring to ants. It isn't clear whether these insects actually prefer these kinds of odours (*PLoS One*, doi.org/gr5rw6).

Plants from the same species emitted different scent cocktails too, which may have something to do with the digestive state of the pitcher. "Maybe, once a pitcher has captured enough prey, it changes or reduces its olfactory signal in order to avoid indigestion," says Gaume. ▮

Space

Starship launches, then explodes

A test of SpaceX's biggest rocket didn't quite go as planned

Leah Crane

STARSHIP has finally launched, but it didn't go smoothly. The SpaceX rocket, the biggest and most powerful to ever fly, lifted off from the Starbase launch facility in Texas on 20 April in its first full test. Shortly after liftoff, it exploded.

It has been a long road for Starship – testing of smaller prototypes since 2019 saw a few successful "hops" of up to 10 kilometres in altitude, but also four malfunctions, three of which resulted in the destruction of the prototypes.

Those tests were all prototypes of the eponymous top part of Starship, the piece of the craft that is planned to eventually house astronauts. The bottom part, called the Super Heavy booster, houses the 33 Raptor engines that propelled Starship off the launchpad.

But less than 5 minutes after liftoff, something went wrong. At that point, Starship and Super Heavy were intended to separate, with Super Heavy splashing back down in the Gulf of Mexico and Starship continuing onward for a 90-minute flight. They didn't separate, and the whole spacecraft began to tumble. Then, it exploded.

"I don't think anybody, Elon Musk included, expected this launch to go perfectly," says space analyst Laura Forczyk. Musk is the CEO of SpaceX. "I would have been shocked if it had been 100 per cent successful this first time," she says.

The explosion occurred when the spacecraft was attempting to rotate so that Super Heavy could return to the ground upright, which has never been done before.

The cause of the tumbling and explosion isn't clear, and SpaceX will have to figure that out before the firm can decide what its next steps are. There were some issues with pressurisation, which caused the first launch attempt on 17 April to be cancelled and a brief delay in the 20 April launch, but it is unclear whether those could be related to the failure of Starship and Super Heavy to disconnect from one another.

"SpaceX is going to determine what went wrong, they are going to improve on the process and they are going to try again. I think we should expect to see multiple tests this year," says Forczyk. "They have many customers that are waiting on this rocket – they have NASA, they have private customers, they have other government interest, so there's a lot waiting on this rocket becoming operational."

Despite the explosion, the test wasn't a complete failure. It demonstrated that Starship can get off the ground, which wasn't a given. "I don't see any reason why today's failure would be a major setback," says Forczyk.

This test flight was the first big step in SpaceX's journey to other worlds. Starship has two crewed flights tentatively planned for later in 2023, and it is intended to carry humans to the moon and eventually Mars, but it will presumably have to be tested further for safety first. ▮

SpaceX's Starship takes off on 20 April (left) then explodes (right)

L: JONATHAN NEWTON/WASHINGTON POST/; REUTERS/JOE SKIPPER/ALAMY

Technology

Edible computer chips could guide robots in the body

MEDICAL robots controlled by edible computer chips could deliver drugs inside the body.

Soft robots that can operate inside the human body are a busy area of research, but they tend to be remotely controlled from outside the body with magnets. Simple computers made from flexible tubes and devices that operate hydraulically – known as microfluidic computers – have been in development for some time to give these robots more complex abilities, but they tend to be made from materials that can't be digested, such as silicon.

Shuhang Zhang at the Swiss Federal Institute of Technology Lausanne and his colleagues are investigating how to create those same designs from material that is safe to eat.

They created a single NOT logic gate – one of the fundamental building blocks that all computer chips are made of – from ethyl cellulose, which is commonly used to create the shell of pills. In the right combination and number, such gates could be used to build simple computers.

A NOT gate takes an input and converts it into the opposite value. The team's prototype gate has two input tubes: one that provides a continuous flow of pressure, like a power supply, and another that represents the data input. When a high-pressure input is supplied – representing a 1 inside a classical computer – a valve is forced shut and the output tube has a low pressure, representing a 0. When a low-pressure input is supplied, representing a 0, the valve opens and the logic gate produces a high-pressure output, representing a 1 (arXiv, doi.org/j668).

"Our target is to build something that works outside the body, and after that something that could be swallowed – but not chewed, to keep the integrity of the structure – that works inside our body," says Zhang. ▮

"Our target is to build something that could be swallowed that works inside our body"

Matthew Sparkes

Animal behaviour

Elephant seals take power naps in the ocean

Michael Le Page

HOW can an air-breathing animal sleep safely in the open ocean, with killer whales and great whites prowling near the surface? For elephant seals, we now know the solution is to dive around 100 metres, then slowly sink up to a further 300 metres while they have a 10-minute snooze.

That is the finding of Jessica Kendall-Bar at the Scripps Institution of Oceanography in California and her colleagues, who have developed a system for recording the electrical brain activity of elephant seals, as well as their heart rates and movements. It consists of a headcap, plus several electrodes that can detect fin muscle contractions, and motion trackers.

After tests on a few captive elephant seals, they attached this system to eight wild female seals with a temporary adhesive. The team didn't do this with males as their much larger size makes it harder to attach any kind of device. Three of these wild seals spent time in the open ocean while the devices were attached, with the others remaining in shallower waters or on beaches.

Northern elephant seals, one with a sleep monitor (right)

JESSICA KENDALL-BAR

Deep sleep

The devices allowed the team to identify how the seals move while in slow-wave, or deep, sleep, and also in rapid-eye-movement (REM), or dream, sleep. Using this, they could look back at previous time-and-depth recordings from more than 300 wild females and identify when they were sleeping and which sleep stage they were in.

The study shows that females out in the open sea sleep for less than 10 minutes at a time during dives and get only around 2 hours sleep per day in total, compared with around 10 hours when they are on land. At around 100 metres or so below the surface, they go into slow-wave sleep and start drifting downwards. "I was really surprised by how much they could maintain their body position," says Kendall-Bar.

But when the animals go into REM sleep, they do lose control. Their bodies turn upside down and sink in a characteristic spiral, with one animal going as deep as 377 metres. Then the seals wake and swim back to the surface. In waters less than 250 metres deep, the seals instead sleep motionless on the seafloor, like other seals do (*Science*, doi.org/j6vf).

2

Total hours of sleep elephant seals get in the ocean each day

Other marine mammals have solved the problem of how to sleep at sea in a different way. Only half of the brains of whales and dolphins sleep at a time, allowing the other half to watch out for danger and maintain breathing at the surface.

Fur seals use the same trick, reported Jerome Siegel at the University of California, Los Angeles, in 2018. Unusually, though, fur seals can do both half and whole-brain sleeping – when they are on land the proportion of whole-brain sleep increases.

Siegel says he isn't surprised that elephant seals get by with just 2 hours of sleep. "We have previously reported that African elephants in the wild average 2 hours of sleep," he says. His team has also found that dolphins and killer whales don't sleep at all for months after birth.

"Sleep duration is not correlated with brain size or cognitive ability," says Siegel. ▮

Technology

Synthetic spider silk laced with graphene can rapidly heal itself

Carissa Wong

A SELF-REPAIRING material made from a protein in spider silk works as an electrical circuit when graphene is added to it.

Hsuan-Chen Wu at the National Taiwan University and his colleagues collected silk from giant golden orb-weaver spiders (*Nephila pilipes*) and dissolved it in the chemical hexafluoroisopropanol.

They dried the solution to create a thin film and made a small cut in it, about 30 micrometres wide, with a razor blade. When they added a few drops of water to the site of damage, it started to heal. After 20 minutes, the scar width had reduced to just 2.4 micrometres.

"This is the first time silk materials from this spider have been shown to have self-healing ability," says Wu. "We think adding water may make the proteins more flexible at the cut site, which helps them form networks to heal the material more quickly."

The researchers identified a protein called R2 as the source of this ability. They modified *E. coli* bacterial cells to produce the protein, then connected the ends of thin strips of it so that they self-healed to form a ring.

Next, the researchers laced another strip with graphene, allowing it to conduct electricity. They fused a layer of this to the ring using water and connected the ring to a circuit board with a display screen. The system could distinguish whether it was being worn on a finger, over nitrile gloves or in contact with aluminium foil based on the flow of electrical current (bioRxiv, doi.org/j7fc).

It is a breakthrough in self-healing biomaterials, says Michael Kessler at Johns Hopkins University in Maryland. "[They] have created a new class of materials that could have a wide range of applications in fields such as biomedicine, electronics and textiles." ▮

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Climate change

2022 was Europe's hottest summer but warmer years are likely to come

Kate Ravilious

IT IS official: last year was a record-breaker for Europe. The continent experienced its hottest summer on record and its second-warmest year, according to the latest *European State of the Climate* report. Released on 20 April, the report also reveals that temperatures across Europe are rising at twice the global average, with the continent having experienced 2.2°C of warming since pre-industrial times.

The figures, which come from multiple data sets including satellite data, in situ measurements and numerical weather prediction models, fit into the wider global heating trend, with global data showing that the past eight years have been the warmest on record.

The probability of getting a warmer year, both globally and in Europe, is going up every year due to rising levels of greenhouse gases, says Samantha Burgess at the Copernicus Climate Change Service, which compiled the data for the report.

"If you imagine a deck of cards where the black cards are cooler years and the red ones warmer years, then the global heating effect is like removing black cards from the deck every year and replacing them with red ones," says Burgess.

No corner of Europe escaped unscathed from 2022's extreme conditions. In western Europe, peak summer temperatures were as much as 10°C greater than typical and, for the first time on record, temperatures in the UK reached 40°C (104°F). Across southern Europe, heatwaves resulted in a record number of days with very strong heat stress – temperatures that feel between 38°C and 46°C (100°F and 115°F).

Firefighters tackle a wildfire in Saint-Magne, France, in August 2022

STEPHANE MAHE/REUTERS/ALAMY

The high temperatures and long sunshine hours resulted in surface ozone concentrations reaching potentially harmful levels across much of Europe. Average sea surface temperatures across Europe's seas were the warmest on record in 2022 and about three-quarters of its lakes were warmer than average, says the report.

The unprecedented high temperatures and low rainfall – 10 per cent less than average – led to widespread drought, resulting in the second-lowest river flow and the second-largest wildfire burn area on record for Europe.

Effects on colder areas were also significant. A lack of snow along with the unusually warm summer caused record melting of Alpine glaciers, which lost more than 5 cubic kilometres of ice.

It was a similar story in the Arctic, according to the report, where 2022 was the sixth warmest year on record and exceptional September heatwaves in Greenland resulted in record-breaking ice sheet melt.

Atmospheric circulation patterns had a key role in creating the extremes of 2022, with stable high-pressure conditions over western Europe generating warm, dry and sunny conditions.

"The findings are all consistent with warming of climate due to the heating effect from our emissions of greenhouse gases," says Richard Allan at the University of Reading, UK. ▮

Space

Heavy element in distant planet is a record find

AN ELEMENT spotted in an exoplanet is the heaviest one yet identified in a world beyond our solar system. Elements like this are expected to be both relatively rare and difficult to spot, but finding them is key to understanding how planets form and evolve.

Wei Wang at the National Astronomical Observatories of China and his colleagues found this heavy element, samarium, in a planet called MASCARA-4b, which is about 557 light years from Earth. MASCARA-4b is an ultra-hot Jupiter, which is to say its outer layers are gaseous and it has surface temperatures of up to 2000°C because it orbits close to its star.

The researchers observed MASCARA-4b using the Very Large Telescope in Chile, analysing a spectrum of starlight filtering through the top of the planet's atmosphere. They found a variety of heavy elements. One of them was barium, which was previously the heaviest element ever spotted in an exoplanet atmosphere with an atomic number of 56. Another was the heavier element, samarium, whose atom contains six more protons than barium and has an atomic number of 62 (arXiv, doi.org/gr5rvn).

"Every star and planet should contain these elements from birth. The question is why they are so abundant to be detected," says Wang.

> "Every star and planet should contain these elements. The question is why they are so abundant"

Spotting so much samarium on MASCARA-4b means that the heavy element hasn't sunk to the bottom of the atmosphere, as we might expect. It also suggests that ultra-hot Jupiters might have fewer lighter elements in their atmospheres than other exoplanets. Because samarium tends to react with water vapour and oxygen, its presence on MASCARA-4b indicates the planet has very little of these substances.

Finding further heavy elements on exoplanets will help us elucidate the compositions of these strange worlds and thus how they form. ▮

Leah Crane

Neuroscience

The brain's other motion controller

For decades, we have known that the motor cortex directs which body parts we move. Now, it seems we missed a crucial part of it, finds **Jason Arunn Murugesu**

OUR movements may be controlled by two distinct networks in our brain, rather than just one as previously thought.

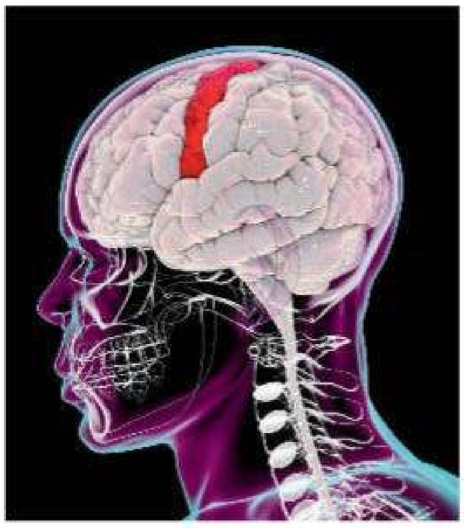
For nearly a century, we have known that the motor cortex – a thin strip of tissue that runs across the top of the brain – controls body movements.

In the 1930s, neuroscientists Wilder Penfield and Edwin Boldrey electrically stimulated the brains of people undergoing brain surgery, showing that different sections of the primary motor cortex control different parts of the body. They also found that these control areas are arranged in the same order as the body parts they direct, with the toes at one end of the cortex and the face at the other, as depicted by the so-called homunculus map, a likeness of a person they drew to represent this pattern (see below).

Evan Gordon at Washington University School of Medicine in Missouri and his team wanted to use modern technology to look into the Penfield-Boldrey idea in more detail. They therefore took high-resolution MRI brain scans from seven people as they lay in a scanner looking at a cross symbol, recording a total of 12 to 15 hours of data over multiple sessions.

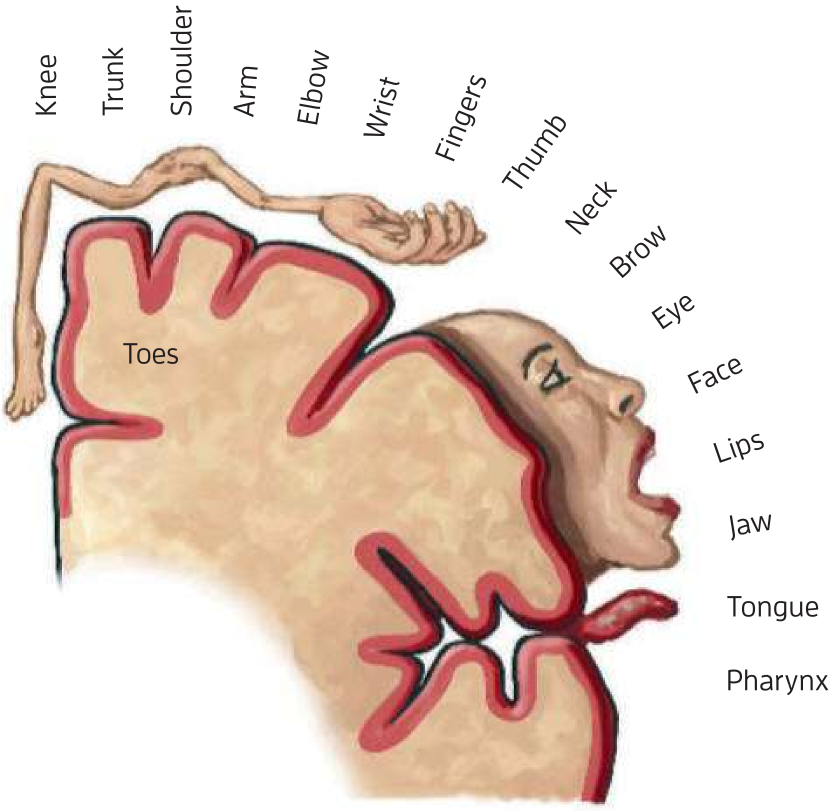
Analysing the participants' brains while they were largely stationary and not engaged in a more sophisticated task, such as reading, meant that their brain activity data was less complex, allowing the researchers to better observe which parts of the brain work together, says Gordon.

The Penfield-Boldrey research suggests that the primary motor cortex is just made up of the homunculus map. But Gordon and his team found that the cortex has three more regions interspersed within the map that appear to work together to coordinate movements to the centre of the body, such as the shoulders and abdomen.


RKATERYNA KON/SCIENCE PHOTO LIBRARY/GETTY IMAGES

The motor cortex sits in the brain's precentral gyrus (shown in red)

Next, the researchers scanned the brains of two of the participants again as they carried out 25 movements, such as winking and swallowing, while lying down in an MRI scanner.



SCIENCE HISTORY IMAGES/ALAMY

The homunculus map depicts how the motor cortex links to body parts

These scans generally support the information outlined in the homunculus map. In simple terms, they show that one region of the primary motor cortex is linked to movements in the lower body; one to hand-related movements, which includes shoulders; and another to facial movements. This corresponds with what Penfield and Boldrey described, and makes up a distinct network in our brain that controls some movements.

From these two participants' scans, the researchers have shown the regions between those on the homunculus map in more detail. These in-between regions become particularly active when the participants moved their midsections. The researchers have named them the somato-cognitive action network (SCAN), which makes up our brain's second distinct motor network.

They then looked for signs of the SCAN in brain activity data taken from several major databases, such as the Human Connectome Project and the UK Biobank, finding that it appears to be present in all of the samples they analysed.

The SCAN network seems to act alongside the first network in the primary motor cortex, which controls movements related to the hands, feet and mouth, says Gordon. Movements of other parts of our body, such as our hips or back, may be controlled by yet more regions of the motor cortex that haven't been mapped in detail, he says.

In another part of the experiment, the researchers scanned the brains of three children – a newborn, an 11-month-old and a 9-year-old – to see if they had the the SCAN.

While they didn't see the network in the newborn, it was in the 11-month-old and 9-year-old, suggesting that it develops as a baby grows (*Nature*, doi.org/j6qp). "An 11-month-old can purposefully move his arms and legs around," says Gordon. "Whereas a neonate has very little control of their body's movements."

The team wonders if the SCAN is involved in conditions such as Parkinson's disease, which affects movement. While further research would be needed to establish this, the SCAN could be a treatment target for Parkinson's and other movement-related conditions like ataxia, says Gordon.

"This is a novel contribution to the long-standing… question in neuroscience regarding the scheme that neurons in [the] motor cortex use to control movement," says Patrick Haggard at University College London. To verify the results of the study, it would be useful to record SCAN neurons in experiments where people or other animals are free to move, not confined to a scanner, he says. ▮

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Health

Skateboard boosts babies' motor skills

RIDING a medical skateboard seems to help premature babies learn to crawl and walk faster.

Marianne Barbu-Roth at Paris Cité University, France, and her colleagues developed the device to give babies born preterm time to practise moving their limbs.

Babies are laid on their front on the skateboard and strapped on so they can't fall. They can then use their arms and legs to propel themselves. In a test involving 44 babies, those using the skateboard could push themselves 139 centimetres forward, on average, during 5-minute sessions.

The skateboarders were more likely to be able to control their head by the age of 2 months, to crawl by 9 months and to stand by 12 months, than babies that didn't get to try it (medRxiv, doi.org/j6rs). **Alice Klein**

Environment

A kelping hand for carbon capture

KELP forests provide an estimated $500 billion in services to the world and capture 4.5 million tonnes of carbon dioxide annually.

Aaron Eger at the University of New South Wales in Australia and his colleagues assessed what help we get from kelp by examining the seaweed's role in the sea and the amount of nitrogen, carbon and phosphorus stored in the seaweed.

Most of kelp's economic benefits come from creating habitat for fish that are important for commercial fishing and from sequestering phosphorus and nitrogen, which can be expensive for us to remove from water (*Nature Communications*, doi.org/gr5h7r). "Much like a plant on land, [kelp forests] are taking up nutrients, they're taking up carbon dioxide and using light to fuel their growth," says Eger. **Corryn Wetzel**

ARCO/G. LACZ/IMAGEBROKER/ALAMY

Zoology

Zebra finches get out of tune if they don't practise daily

SONGBIRDS may need to sing every day to maintain the quality of their performance.

Male zebra finches (*Taeniopygia guttata*) learn a unique song, usually from their father, in the first 90 days of their life. They then sing thousands of variations of it daily. The songs are used to attract a female partner, but birds continue to sing when they are isolated.

Now, Satoshi Kojima at the Korea Brain Research Institute in Daegu, South Korea, and his colleagues have discovered that having a break from crooning affects the quality of a zebra finch's song.

They stopped 16 adult male zebra finches from singing for two weeks by placing a small weight on their necks that prevented them from getting into a posture that allowed them to sing. The weight didn't significantly affect the birds' ability to eat or drink, says Kojima. The researchers removed the weight at night, as the birds don't typically sing at this time.

When the birds were able to sing again, they sang at a lower pitch and for a shorter length of time, although they maintained the structure of their songs (bioRxiv, doi.org/j6tw).

A further experiment suggested that the change was due to a lack of muscle use – particularly the muscles in the vocal organs, called syringeal muscles. "If the [singing] muscle gets weaker, the birds cannot make a high-frequency, high-pitch sound," says Kojima.

After two weeks of being able to sing again, the finches returned to their former performance level.

"I suspect that other birds which sing will also need to practise daily to maintain their abilities," says Kojima. **Jason Arunn Murugesu**

Really brief

SERGEY LEVINE/GOOGLE

Google's robot sorts out office waste

Robots that have been roaming Google offices for two years can now separate recyclable items from waste in bins with an accuracy of 84 per cent. About 40 robots, some roving and others at workstations in a robot classroom, share the same AI model, so as one learns, they all do.

Big animals go slow to stop overheating

For animals that weigh more than a tonne, the difficulty of staying cool while travelling is the key limiting factor for their speed, regardless of whether they run, swim or fly. This suggests global warming will be a bigger problem for large animals than we thought (*PLoS Biology*, doi.org/gr5jn9).

Sea urchin death culprit revealed

The mystery cause of a mass die-off of sea urchins has been identified as a parasite called a ciliate. Up to 95 per cent of the long-spined sea urchins on Caribbean reefs died in January 2022, infected by *Philaster apodigitiformis*, a tiny organism covered in hair-like structures (*Science Advances*, doi.org/gr5pqd).

AN IMPORTANT MESSAGE FROM PROFESSOR NICK LEMOINE CBE MD PHD FMEDSCI, CHAIR OF THE MEDICAL RESEARCH FOUNDATION

Gifts in Wills could be the key to protecting the future of human health

Our experience of COVID-19 shows how suddenly a global health challenge can appear. As someone interested in science, you will understand that while nobody can predict what we will face next, we can be certain that the future will bring many more threats to human health.

As Chair of the Medical Research Foundation – the charitable arm of the Medical Research Council – I have seen the incredible impact that individuals who remember the Foundation in their Wills can have on the future of our health and wellbeing here in the UK. These gifts fund research and researchers which can have far-reaching implications for human health.

With a gift in your Will you can play a key role in providing the science that will protect the health of future generations.

Right now, the Foundation is funding research to tackle antimicrobial resistance, and investing in researchers like Dr Myrsini Kaforou – who will make the fight against antimicrobial resistance her life's work. Without support at the crucial early stages, researchers like Dr Kaforou can be forced to abandon their passion and leave science altogether, with an immeasurable loss to future human health. Gifts in Wills provide the long term funding and security that allows the Foundation to invest in projects like Dr Kaforou's and lay the foundations for quality research in years to come.

Your Will can fund the rational response to health challenges that medical science provides.

> **"As scientists, our duty is to secure the future of research for the generations that follow."**
>
> Professor Fiona Watt, Patron of the Medical Research Foundation and Director of the European Molecular Biology Organization.

While we don't know what the future holds for human health in the UK, we do know that research, and the brilliant scientists driving that research forward, are the key to meeting those challenges for years to come.

Changing medicine today. Changing lives tomorrow.
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"The funding I received through the Medical Research Foundation will be transformative for my research." Dr Myrsini Kaforou

But many of these scientists rely on the generosity and foresight of fellow members of the public – people like you, who understand the power of science and are willing to leave a gift to medical research in their Wills. At the Medical Research Foundation, over 90% of our voluntary income comes from individuals who choose to include a gift in their Will – they are crucial in the Foundation's ability to fund research that will enable the next generation of scientists to make real world discoveries in the future.

I firmly believe that a gift in your Will to the Medical Research Foundation is an excellent investment and will have a lasting impact on science and on the future of human health in the UK.

Please consider this very special gift today.

Professor Nick Lemoine CBE MD PhD FMedSci
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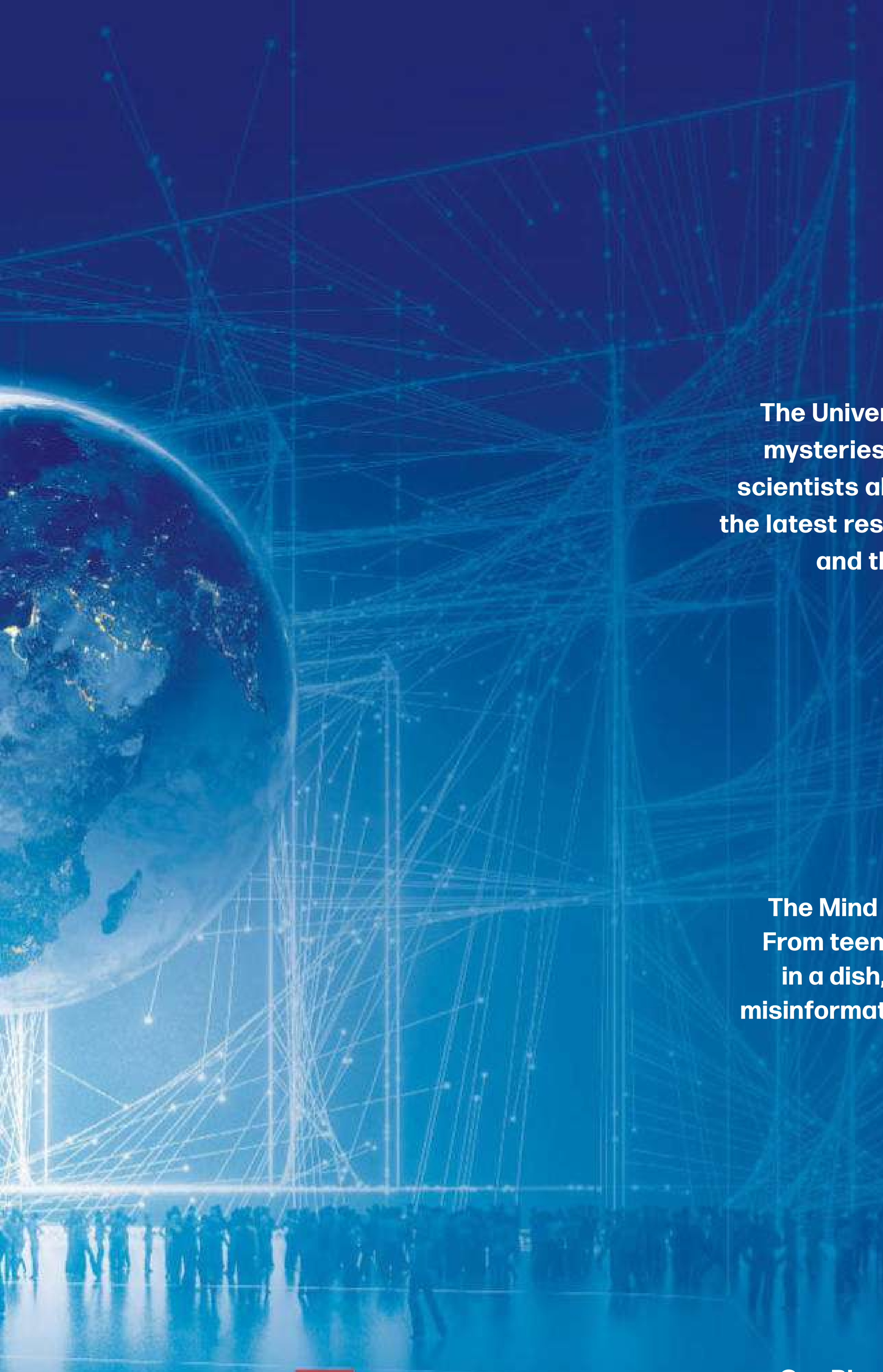

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The Universe Stage is your place to hear about the mysteries of the cosmos. Hear from world-leading scientists about the JUICE mission to Jupiter's moons, the latest results from the James Webb Space Telescope and the quest to photograph a black hole.

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Ancient caves, human origins: Northern Spain

Accompanied by *New Scientist* Editor-in-Chief, Emily Wilson

13 June 2023 | 7 days From £2999

Throughout this tour, you will be accompanied by *New Scientist* Editor-in-Chief, Emily Wilson along with local archaeological experts and cave custodians, who will give specialist talks and walking seminars over the seven days.

This is a unique opportunity to discover some of the world's oldest known cave paintings in this idyllic part of Spain and travel back 40,000 years to explore how our ancestors lived, played and worked. Experience the wonders of several renowned caves full of art from before the dawn of civilisation including El Castillo, Las Monedas, La Peña Cave, El Pindal and Tito Bustillo in small groups by torchlight. Visit the stunning replica of Altamira, the Museo de Evolución Humana and the Archaeological Museum of Santander.

Highlights

- Travel to Burgos to visit the Museo de Evolución Humana, where you will learn about the archaeological and palaeontological history of the surrounding Atapuerca mountains, the many stages of human evolution and the story of Charles Darwin's exploration around the world that led to the theory of evolution.
- You will visit the caves of El Pindal, containing the first palaeolithic cave paintings discovered in the region, the most notable of which is a woolly mammoth.
- In the charming coastal town of Ribadesella, you will visit the Tito Bustillo cave before traveling south to the Cave El Buxu. Discovered in 1916, this cave houses both paintings and engravings.
- In Candamos, you will visit La Peña Cave, the largest cave with rooms leading off it, this cave contains several different panels of art dating back 18,000 years and covering several species.
- Visit El Castillo, home to one of the oldest known cave paintings, dated as more than 40,000 years old. Located in Puente Viesgo, it is situated in a limestone hill, which hides an intricate labyrinth of caves frequented by prehistoric humans.
- You will travel east to Santander to visit the Archaeological Museum, where you will see an array of artifacts, interactive guides and vivid interpretations of stone age life.
- Spend time at the world-famous Guggenheim Museum, viewing the modern and contemporary art in this stunning Frank-Gehry-designed building, an awe-inspiring monument to design modernism.
- This tour will also depart on 29 August and be accompanied by *New Scientist* feature editor Kate Douglas.

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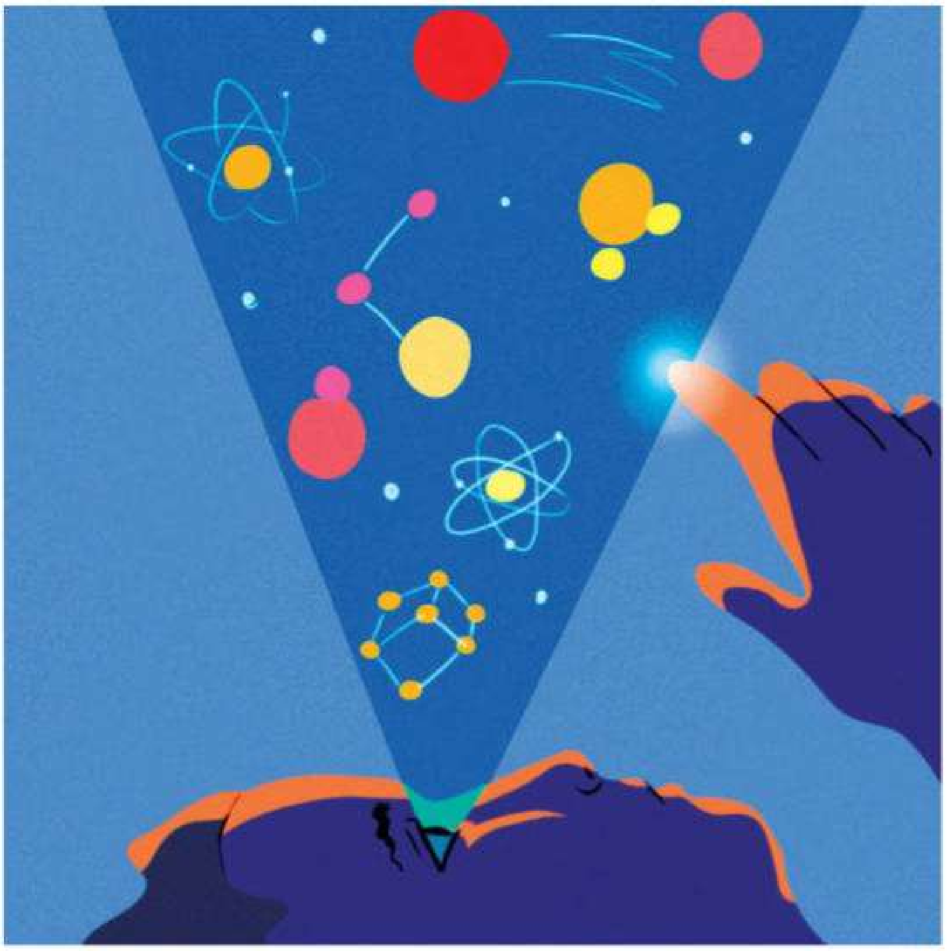
Comment

Practical magic

Condensed matter is a huge field of physics that gets less attention than it deserves. We need to start inspiring people, says **Felix Flicker**

CONDENSED matter is the largest field in physics, employing a third of all researchers. So why is it almost unknown to the wider public? Essentially, for two reasons: it is familiar and it is practical. Neither property is compatible with the sense of magic that draws the public to science, apparent in topics such as black holes or the recent discovery of "the hat", a shape that tiles only "aperiodically". But the familiar and practical are inherently magical – theirs is just a more subtle magic. Learning to appreciate it could popularise the subject and draw in a diverse set of condensed matter physicists for the next generation.

Let us define magic as the ability of nature to inspire. Well-known fields of science have undeniable magic to them. Black holes are magical and recent images of them have inspired people around the world. The hat is a piece of mathematical magic: sought for decades, it was eventually found to be a remarkably simple 13-sided polygon. But can we be so inspired by the familiar and the practical?



MICHELLE D'URBANO

Between the unfathomably large and the unimaginably small lies the world of our everyday experience. Its study is condensed matter physics, which investigates matter and how it emerges from the quantum world of atoms and molecules. It is inherently practical: from computers to phones to energy-efficient lighting, we developed modern technology by understanding its constituent matter. But practicality and familiarity limit public excitement about matter.

Perhaps the most magical aspect of condensed matter physics is how it explains our world in terms of the quantum realm. For example, identical molecules at 0°C (32°F) form liquid water or solid ice. The difference is familiar: dipping your finger in the ocean is easy, but moving an iceberg with the same finger is impossible. The iceberg performs this magic by having its atoms behave collectively: try to push a single molecule of H_2O and the others resist the push together. This is because their oxygen atoms are locked into a regular, periodic structure – a crystal. A crystal is more than just its atoms: it is the ordered structure they form.

Could there exist some exotic matter in which the atoms appear not periodically, as in crystals such as ice, but aperiodically, as in the tiling of "the hat"? A few decades after the discovery of the first (multi-tile) aperiodic tiling, a new state of matter was found whose atoms matched the pattern. It was dubbed a "quasicrystal". Only three naturally occurring examples have ever been found, all in the same Siberian meteorite. Their aperiodic nature grants quasicrystals some remarkable properties, which have led to proposals for practical uses.

Regardless of practicality, the scientist must always be part magician. Popularising science isn't a matter of teaching – it is a matter of inspiring. Black holes have this power in abundance. But condensed matter has it too and, by harnessing it, condensed matter physicists will be able to teach the public about the practical applications of their subject, as well as generate the sense of wonder that has driven them to study it.

This is important because there are many people who have been told by society that science isn't for them. Undoing this conditioning is a vital step in widening access to physics, condensed matter physics in particular. The health of the subject is at stake: to answer the biggest questions about the world, we require the broadest possible range of world views. The hat, for instance, was discovered not by a mathematician, but by a retired print technician who describes himself as a "shape hobbyist". This is where the magic comes in. Because, while some may not feel a connection to science, we all have an intuitive sense of magic – of the world's ability to inspire. ▮

Felix Flicker is author of *The Magick of Matter*. He is organising a public conference about "the hat": bit.ly/hatfest23

Field notes from space-time

The nature of a proof A 2021 paper has got physicists discussing whether the boundaries we imagine for Newtonian physics are simply failures of imagination, finds **Chanda Prescod-Weinstein**

Chanda Prescod-Weinstein is an assistant professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her research in theoretical physics focuses on cosmology, neutron stars and particles beyond the standard model

Chanda's week

What I'm reading

I'm still working through the Taylor Branch trilogy about Martin Luther King Jr.

What I'm watching

Like many people, I spent an hour watching a hold screen on Netflix while waiting for the live Love is Blind *reunion. Wah wah.*

What I'm working on

I am thinking deeply about how I want to spend my time this summer.

This column appears monthly. Up next week: Graham Lawton

I ALMOST didn't write this column because I worried that it might give people the wrong impression about quantum mechanics. So let me start by saying that I wholeheartedly believe that quantum mechanics is a correct description of reality on a micro scale. If there are limits to how correct it is, those are likely to involve questions about how to combine quantum mechanics and gravity, which we have so far been unable to do with a testable model.

Here is why I began with that preamble: one of the interesting challenges that quantum mechanics presents to us is that while the mathematical structure of it is clear, we aren't entirely sure how to interpret what the equations are telling us. In other words, we can write down equations that make accurate predictions about experiments, but we aren't always sure what that implies about what actually happened, physically, before any measurement occurs.

This may or may not be a problem. In the textbook I am using to teach this semester, *Quantum Mechanics*, Arjun Berera and Luigi Del Debbio write: "Beyond any theoretical sophistication, a physical theory is first and foremost a description of natural phenomena; therefore it requires a very precise framework that allows the observer to relate the outcome of experiments to theoretical predictions."

From this perspective, quantum mechanics is incredibly successful. We have a theoretical framework – derived from the advanced mathematics of linear algebra – that allows us to determine what experimental outcomes we should expect.

Yet the microphysical world has all kinds of phenomena that we often describe as weird and out of sync with a classical, Newtonian picture. Consider the famed double-slit experiment in which a light beam is aimed at a plate with two parallel slits, behind which is a screen that detects the subsequent light pattern. First, the outcome of this experiment shows that light behaves like a wave and a particle simultaneously. Similar experiments with, for example, electrons display this same wave-particle duality. Second, the experiment set-up shows that a particle's behaviour depends on whether we engage in the act of observing it or not. Third, and perhaps most jarringly, these outcomes also imply that particles don't exist until we observe them.

> "Importantly, the goal of these researchers isn't to convince us that quantum mechanics is a wrong theory"

In a 2021 paper, Lorenzo Catani, Matthew Leifer, David Schmid and Robert W. Spekkens named these three outcomes the "traditionally regarded as problematic", or TRAP, phenomenology. The TRAP phenomenology forms the basis for our arguments that quantum mechanics is necessary. We simply cannot explain the phenomena using classical physics, we tell ourselves, our students and intrepid readers of publications like *New Scientist*.

But, as Catani, Leifer, Schmid and Spekkens pointed out, perhaps our inability to use classical physics to explain the TRAP phenomenology is a human failing and not proof that the universe is more complex than Isaac Newton imagined. In their paper, which is the subject of active debate, they developed a classical theory that can describe the TRAP phenomenology without reference to the quantum framework.

Importantly, the goal of these researchers isn't to convince us that quantum mechanics is a wrong theory. Instead, they want scientists to do better when it comes to proving the claims we are making about how the universe works. Rather than simply arguing that experiments displaying apparent quantum behaviours require us to move to a quantum theory framework, scientists should prove that it is absolutely impossible to develop a theoretical framework using only classical ideas.

What they are talking about is the idea of a "no-go theorem": a proposition that states a particular outcome is simply not possible. Physics is replete with such theorems, some of which are proven and some of which are still just ideas that may or may not be true. For example, in 1842, Samuel Earnshaw mathematically proved that a collection of charged (classical) particles won't stay stable and motionless if the only force at work between them is the electric force. This is an example of a no-go theorem that has been proven.

There are other no-go theorems throughout theoretical physics that remain unproven hypotheses. And there is no rule saying that no-go theorems are a necessary feature of a good physical model.

Catani, Leifer, Schmid and Spekkens have raised a point that, until I read their paper, I had never really considered: are the boundaries we imagine for classical physics simply failures of imagination? If those boundaries are real, then we should be able to prove that a quantum framework is necessary. ▮

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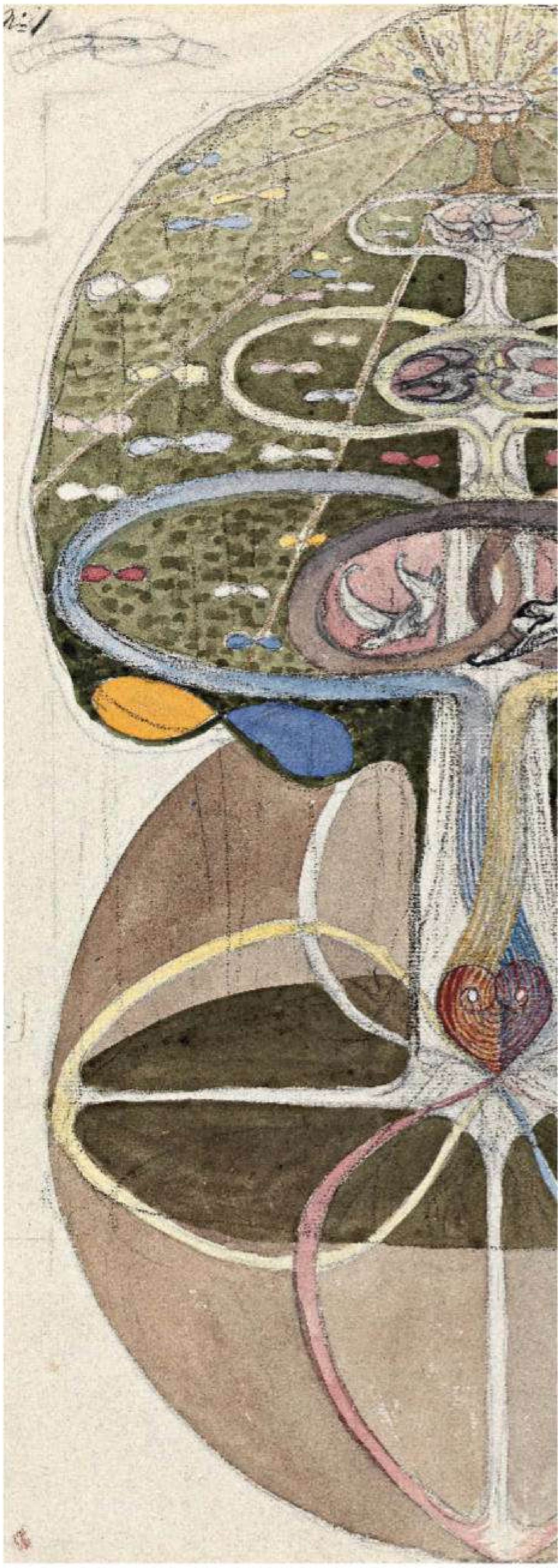

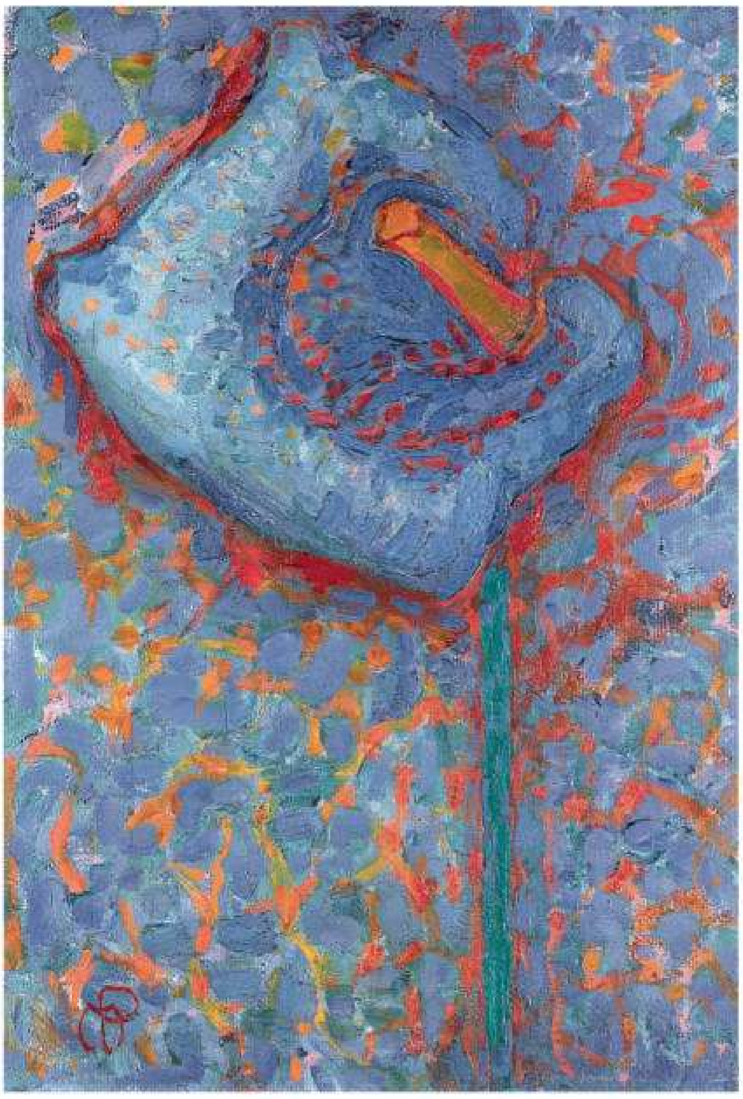

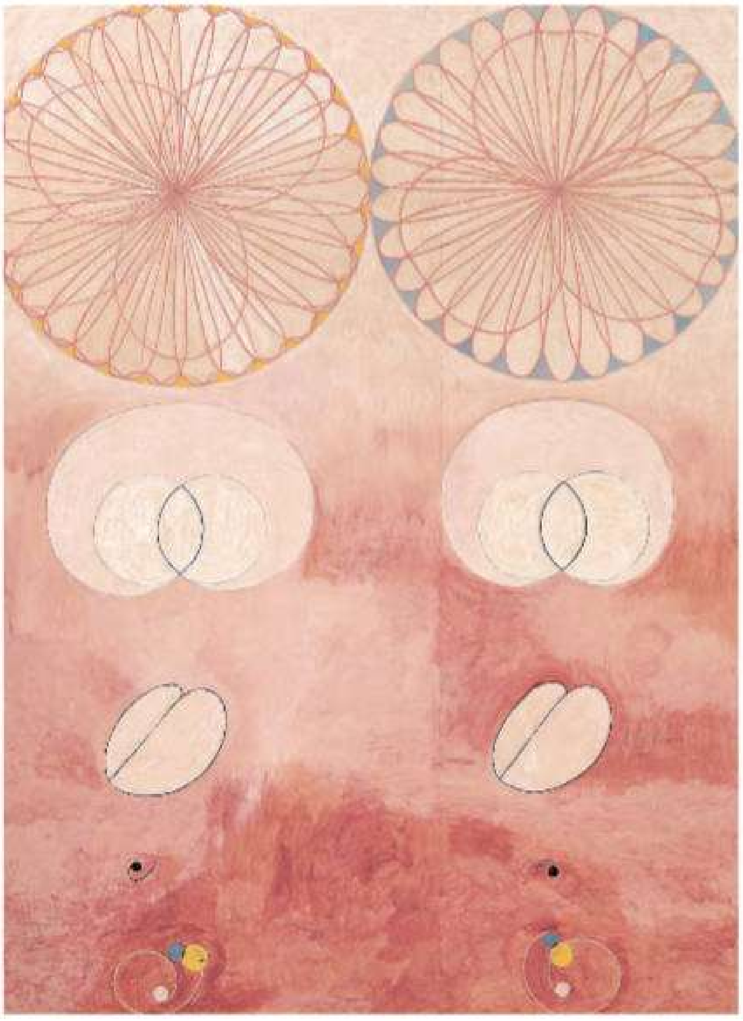

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Abstract nature

Hilma af Klint & Piet Mondrian
Tate Modern

AT THE Tate Modern gallery in London, two pioneering artists who never met are finally brought into conversation.

Hilma af Klint and Piet Mondrian trained as landscape painters in the late 19th century – af Klint in Sweden, Mondrian in the Netherlands. They also died in the same year, 1944, by which time each had developed a unique abstract style.

Both worked in an era coming to terms with huge advances in microscopy, radiography and photography. The world available to the human senses had been revealed as a mere sliver of that accessible to science.

Each artist's output included what we would now call scientific "visualisation". Af Klint conveyed insights about how things grow in paintings inspired by botanical illustration, as in *No. 9, Old Age* from The Ten Largest series (bottom right). Mondrian's interest in the mechanics of visual perception saw him break images down to their perceptual units, so that his *Arum Lily; Blue flower* (top right) is an assembly of lines, lozenge shapes and diagonals.

Af Klint's "world tree" paintings grew almost diagrammatic in their effort to express the cosmic connections between all life, as in *Tree of Knowledge* (main image). Her attempts to map her own perceptual associations are more startling still. The two works at far left are the culmination of a series that began with an image of two swans. Shown here are *The Swan, No. 19* (top) and *No. 17* (bottom), from The SUW Series, Group IX.

Hilma af Klint and Piet Mondrian: Forms of life is at the Tate Modern until 3 September.

Simon Ings

Editor's pick

Is there any need for AI that thinks like us?

1 April, p 10

From Martin van Raay, Culemborg, The Netherlands

Your article asks: are chatbots really able to think like people? I think not. Not as long as they don't feel fear, pride or anger. What we would need for that aren't electronic computers, but chemical ones.

Juxtaposed to this was an article reporting that the global population could reach 8.6 billion people in 2050 (1 April, p 11) – each one of them a chemical computer, each one of them a human intelligence.

So my counter question would be: do we really need artificial intelligence that is able to think like a human being?

Wonder tile may prove elusive in reality

1 April, p 20

From Robert Cailliau, Prévessin-Moëns, France

"I would put it in my bathroom if I were tiling it right now," says Colin Adams of the aperiodic "einstein" tile that has just been discovered.

Sure, if he can find a factory to make both the tile and its mirror image. The tiling pattern needs both. Real bathroom tiles are glazed on one side and are terracotta on the other, so you can't just turn them around. That is a detail that the tile production engineer unfortunately can't overlook.

Technological climate solution may hinder us

8 April, p 11

From Berwyn Powell, Llandrindod Wells, Powys, UK

Your recent analysis of the UK government's *Carbon Budget Delivery Plan* highlights what I feel is a worrying trend in our discussions about climate change.

As our attempts to decarbonise lag ever further behind our goals that aim to prevent the more severe consequences of a warming world, talk is focusing more and more on the need to rapidly curtail greenhouse gases. Technologies such as geoengineering and carbon capture are seen by many as playing a vital role in this.

I fear that by focusing on these innovations, we forget that societal change is the only way we will ever achieve true sustainability. By placing our bets on technological solutions, I worry we will only push the problem further down the road.

Sketching hands is a test for human artists too

15 April, p 16

From John Davies, Lancaster, UK

It isn't just AIs that have difficulty drawing hands. My great-grandfather, as an aspiring sculptor, was only admitted to classes in drawing at the Royal Academy in the UK after he had submitted his drawings of hands. This subject was considered to be a test of talent.

More tips to get the most from your asparagus crop

8 April, p 51

From Tony Power, Sydney, Australia

To add to your pointers on growing and using asparagus, Harold McGee, in his book *On Food and Cooking*, noted that it consumes its sugars faster than any other common vegetable, converting them to fibres from the base up. This process is accelerated by warmth and light.

He recommends soaking asparagus in a 5 to 10 per cent sugar solution before cooking. I have had success in trimming off the bottom 5 millimetres of the stalks, which provides a fresh surface for the liquid. I place them base down in sugar solution – tips in the air – before putting them in the fridge for a few hours, where it is cold and dark. This produces sweet and juicy asparagus.

Could liquid sponges be key to energy transition?

11 March, p 43

From Markus Eymann, Edmonton, Alberta, Canada

I enjoyed reading about the invention of liquid sponges. However, there was no mention of using them to store hydrogen.

Hydrogen storage could be a way to stockpile energy from renewable power. Hydrogen can be produced by electrolysis of water, and later burned or used in fuel cells to create energy, but it is difficult to store in a way that is safe and effective. It seems to me that finding a molecular cage that can more easily hold a hydrogen molecule could be a solution. Of course, we would have to make sure that this material didn't become a new source of pollution.

Electrified by new ideas for tackling human illness

8 April, p 8

From Gautam Menon, Walsall, West Midlands, UK

The idea of implanting a hypoxia-inducing battery near cancerous tissue to improve the function of hypoxia-activated prodrugs (HAPs) for cancer treatment was thought-provoking. You also had an article on the human electrome (25 February, p 38) that commented on cellular voltage patterns and the characteristic electrical signatures of cancer cells.

I wonder if changes to the electrome could be induced with implanted devices to propagate a hypoxic milieu and further boost the action of HAPs on cancers.

Want to get in touch?

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We need a parallel system to keep rain out of sewers

25 March, p 42 (UK edition)

From Bruce Denness, Niton, Isle of Wight, UK

Among the comprehensive range of pollutants in your excellent piece on the state of British rivers is sewage, resulting from drains being overwhelmed by heavy rain.

The spills are discharged from dual-purpose sewage systems that can carry both waste and run-off from rainfall. There will continue to be spills until the existing pipes are replaced with twin piping or a separate system is built to handle rainfall. The widespread digging up of streets for broadband fibre installation is surely a missed opportunity for either option.

Take the long view with a little help from nature

25 March, p 46

From John Stevens, Bad Münstereifel, Germany

A simple way to encourage far-sighted thinking would be to make it mandatory for every school-leaver to plant a tree. This would root in our minds a sense of a future further down the line than the end of our short-termist noses.

Banish those wrinkles... with a bit of chicken soup

1 April, p 38

From Simon Goodman, Griesheim, Germany

In a broad look at the link between wrinkles and age-related decline, Graham Lawton describes research on the efficacy of oral collagen supplements in fighting wrinkles. Of course, supplements tend to be costly. A cheaper and more nourishing solution is traditional chicken soup. As long as you add some lemon juice to bring the pH down, boiling up a chicken carcass will extract quite a lot of collagen. ▮

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JOHN C MATHER

An infectious history

From the rise of farming to pandemics, pathogens have helped mould human civilisation, says a new book. **Elle Hunt** finds plenty of surprises

Book
Pathogenesis
Jonathan Kennedy
Torva/Penguin

FROM the impact of epidemics on the rise and fall of empires to the part played by the Black Death in hastening the transition from a feudal, religious society to a capitalist, secular one, humankind has always taken advantage of (or fallen victim to) "circumstances created by microbes", argues a new and timely book.

Pathogenesis: How germs made history is the first book by Jonathan Kennedy, who teaches global public health at Queen Mary University of London. He draws heavily on that background, spanning 50,000 years of world history and multiple disciplines to write compellingly and persuasively about the role of infectious diseases in shaping the planet as we know it.

His book is full of surprises. For instance, the evolutionary success of our species over Neanderthals may have had less to do with our relative sophistication and superiority, and more to do with the triumph of the immune system of *Homo sapiens* over that of our extinct cousins.

Similarly, Kennedy describes how the Neolithic agricultural revolution enabled the spread of pathogens to the benefit of some and the great disadvantage of others, making the impact of that transformation on human civilisation far more nuanced.

In fact, by moving us away from a nomadic way of life and centralising our food sources, the rise of settled agriculture may have ushered in "a golden age for viruses, microbes and other animals... an epidemiological revolution" that might have had just as much of an impact on the world we live in as the other changes that farming wrought.

The immunity that widely developed as a result may even show in our DNA, with many genetic adaptations roughly coinciding with the switch to an agricultural system.

Too small to easily register in fossil records, the influence of infectious diseases is nonetheless evident as a force running with (or against) so much historic human progress across the globe, driving political and economic change.

For Kennedy, infectious diseases have been a guiding hand at every stage of humanity. For example, the Antonine and Cyprianic plagues in the 2nd and 3rd centuries may have been a factor in transforming Christianity from a small sect into a global faith, with the promise of everlasting life after death never more attractive than in the face of widespread mortality.

Much later, towards the end of the 17th century, a Scottish attempt to set up a trading post in Central America was devastated by an outbreak of yellow fever, leading to the threat of financial ruin for Scotland, a bailout from England and, ultimately, the Act of Union in 1707, which saw the countries combine to become the United Kingdom of Great Britain.

> "*Pathogenesis* offers a humbling reminder that history is made by those who survive"

When it comes to its relevance to current events, *Pathogenesis* isn't just timely because we are living through a pandemic. As Kennedy observes, for all the clichéd talk of unprecedented, extraordinary times, "when we place coronavirus in its historical and scientific context, it becomes very clear that there is little about it that is new or remarkable".

The advent of covid-19 has transformed our world, just as the Black Death and past waves of disease did. Kennedy shows that the widespread sense of there being a pre and a post-covid-19 era – like a "before and after" marker in time – is justified and likely to be borne out by history.

Pandemics, however, will keep coming, exacerbated by the worsening climate crisis. As he warns in his brief, but sobering, final chapter on "future plagues", *H. sapiens* now finds itself in "a very precarious position... surrounded by innumerable viruses and bacteria that are mutating all the time" and face-to-face with the existential threat of infectious disease.

At this moment of reckoning over humankind's planetary footprint, *Pathogenesis* offers a humbling reminder that history is made not by the great or the good, but by those who survive – and that we are just another species of animal.

Elle Hunt is a writer based in Norfolk, UK

A painting of an 18th-century doctor in Venice wearing a plague mask

DE AGOSTINI/GETTY IMAGES

Moving mountains

Max Stainton-Parfitt, who has cerebral palsy, makes an epic journey to Everest South Base Camp, finds **Katie Smith-Wong**

Film

My Everest

Carl Woods

UK cinemas from 28 April

Max Stainton-Parfitt (front) with supporters and Sherpas on his way to Everest South Base Camp

IN 2018, Max Stainton-Parfitt became the first person with cerebral palsy to reach an Everest base camp on horseback. His journey is the focus of *My Everest*, a new documentary written and directed by Carl Woods.

When the documentary opens, Stainton-Parfitt is candid about his mission and his disability. "I'm doing this mad thing to prove people wrong," he says. In the first few moments of the film, Stainton-Parfitt acknowledges that he faces difficulties that others don't, yet he is willing to venture to one of the most challenging locations on Earth.

The fact that Stainton-Parfitt doesn't let cerebral palsy define his life is borne out by childhood videos included in the documentary. They show him as a son and a big brother – never saying a word about his disability. This mindset continues into adult life, as he becomes an avid horse rider via the Riding for the Disabled Association (RDA) and moves to London from elsewhere in the UK, proving that cerebral palsy doesn't stop him from living an independent life.

Though cerebral palsy causes many daily tasks to be a struggle, Stainton-Parfitt faces them with good humour. For instance, he jokes about his preference to talk about finance rather than take off a shirt, displaying lightheartedness about a condition that regularly proves challenging. And he often shows that he chooses to defy societal expectations of people with disabilities.

But the jokes fall away once Stainton-Parfitt sets his mind to conquering Mount Everest by trekking to the mountain's South Base Camp on horseback. He is quickly confronted by the immense physicality of his mission, the daunting climbing altitudes and the rough terrain of Nepal.

Through intimate interactions and stunning cinematography, director Woods follows each step of the journey with compassion and care, reminding audiences that Everest doesn't make exceptions – and that Stainton-Parfitt is enduring environments and conditions that would test anyone.

As progress continues towards South Base Camp, *My Everest* becomes increasingly about the human spirit, with Stainton-Parfitt's support group assisting him.

His RDA and Sherpa supporters, as well as his partner Candy, also have to contend with the high altitudes and thinning air, along with the possibility of not being able to continue. Nonetheless, they consistently make Stainton-Parfitt their priority and share a collective desire to see him succeed, culminating in a poignant moment of triumph.

While Stainton-Parfitt makes a charming protagonist, *My Everest* also offers audiences rare insights into what happens after an achievement such as this. Despite raising funds for the RDA and being the focus of media appearances, Stainton-Parfitt is humbled by what he set out to do, particularly as he has to reckon with the expedition's physical toll.

In one of the documentary's more bittersweet interviews, we see him confess his fear not just for his own well-being but for those around him, leading to a frank discussion of his limits and how far he was willing to push himself just to prove people wrong.

It is a contemplative conclusion, and the unexpected pivot brings a moment of clarity, acceptance and maturity for audiences and the ambitious man they have been following.

My Everest is the story of a determined individual who wants to prove that anything is possible. In so doing, he exceeds expectations, not only by enduring harsh conditions but by pushing his own personal limits. ■

Katie Smith-Wong is a film critic based in London

Don't miss

Watch

Silo is a TV adaptation of sci-fi novel *Wool*, with a cast including Rebecca Ferguson and Common (above). Earth's last 10,000 people live deep underground – but no one can remember why. Streaming on Apple TV+ from 5 May.

Read

The Experience Machine outlines one of the most unusual ways to think about the brain. Philosopher Andy Clark reveals how experience is a more-or-less reliable illusion, created as the brain tries to predict reality. On sale from 2 May.

Visit

A Cosmologist's Guide to Life and Love with Julian Mayers spans time travel, Brexit and why a physicist should speak at your funeral. Watch the show at the Caxton Arms in Brighton, UK, at 12.30pm BST weekly from 7 to 28 May.

APPLE TV+

Reversing the sands of time

A new podcast series that digs into a controversial attempt to “cure” biological ageing is full of suspense, finds **Sandrine Ceurstemont**

CARLO107/E+/GETTY IMAGES

***Buying Time* touches on new developments in anti-ageing research**

Podcast

Buying Time

Big Light Productions and Vespucci
Audible Original, from 27 April

IS IT possible to reverse ageing? In 2015, Seattle-based biotech company BioViva announced it had injected someone with experimental, anti-ageing gene therapies at a secret location outside the US. It later declared that the trial was successful and that changes to the individual’s white blood cells were equivalent to winding the clock back 20 years.

“If it was true, this had revolutionary, world-changing potential,” says journalist Frank Swain, a former staffer at *New Scientist*, in a new podcast he hosts called *Buying Time*. But BioViva’s claims left a lot to the imagination, from the identity of the patient to what dose had been given, which drove Swain to investigate them in the six-part series.

Gene therapies themselves – techniques that treat a condition by modifying a person’s genes – are still in their infancy and only a few have been approved to target certain types of cancer and rare diseases. Furthermore, BioViva’s experiment was controversial, as the firm didn’t do the pre-clinical work that is required for a human trial to be permitted in the US.

However, Elizabeth Parrish, the company’s CEO, seemed confident and personable. She had also recruited an impressive team of scientific advisers, including George Church, a pioneering geneticist based at Harvard Medical School, and Bill Andrews, a molecular biologist whose career has focused on finding a cure for ageing. “It’s because new technology holds so much potential that I’m compelled to scrutinise it,” says Swain.

Early in the series, *Buying Time* reveals who the mystery recipient of the treatment was and where the experiment took place, which has been public knowledge since 2015. But that is only the beginning and there are other key details to uncover. Swain also meets Andrews, the scientist who developed the dual gene therapy that BioViva used, who claims he would never have given it to a human himself. Swain also talks to Parrish twice and discovers a medical tourism company charging high prices for unproven treatments that BioViva seems to be working closely with. The podcast is full of suspense as each episode throws up new questions about the company’s activities.

“In the view of BioViva CEO Elizabeth Parrish, ageing is a disease that is the number one killer on the planet”

In his search for answers, Swain tries to uncover Parrish’s motivations. She says, for example, that she is trying to save lives: in her view, ageing is a disease that is the number one killer on the planet. Although we are now typically living longer than before – partly due to better medical interventions – this also means that we are more likely to develop age-related conditions, such as Alzheimer’s disease and cancer, which can lead to a slow demise. “This is considered [to be] normal,” says Parrish. “Actually, what’s normal is for science to overcome these things.”

Parrish appears to be on a mission to cure ageing, but her credentials don’t make her a conventional fit for the part: she is neither a doctor nor a scientist. BioViva latches onto mainstream research though, for example by referencing work by María Blasco, the director of the Spanish National Cancer Research Centre in Madrid, who features in the podcast.

By treating mice with a gene therapy that is similar to one of those used by BioViva, Blasco and her team were able to delay age-related diseases in the rodents and cause them to live longer. Like Parrish, Blasco is tackling ageing due to its link to these diseases. However, the difference is that Blasco’s team isn’t sidestepping accepted procedures. “I think regulations are important,” says Blasco. “It’s a way to, first, demonstrate that something is working for real and isn’t just a placebo effect, and, second, to be sure that it is not toxic.”

New developments in anti-ageing research featured in the show are fascinating and should have had more airtime. Swain also touches on practical, ethical and philosophical questions that come into play when aiming to extend our healthy lifespans. Does such an undertaking devalue the lives of people with disabilities or chronic conditions? And what will happen to the population if we can all be rejuvenated? Perhaps we need to become a bit older and wiser first. ▮

Sandrine Ceurstemont is a writer based in Morocco

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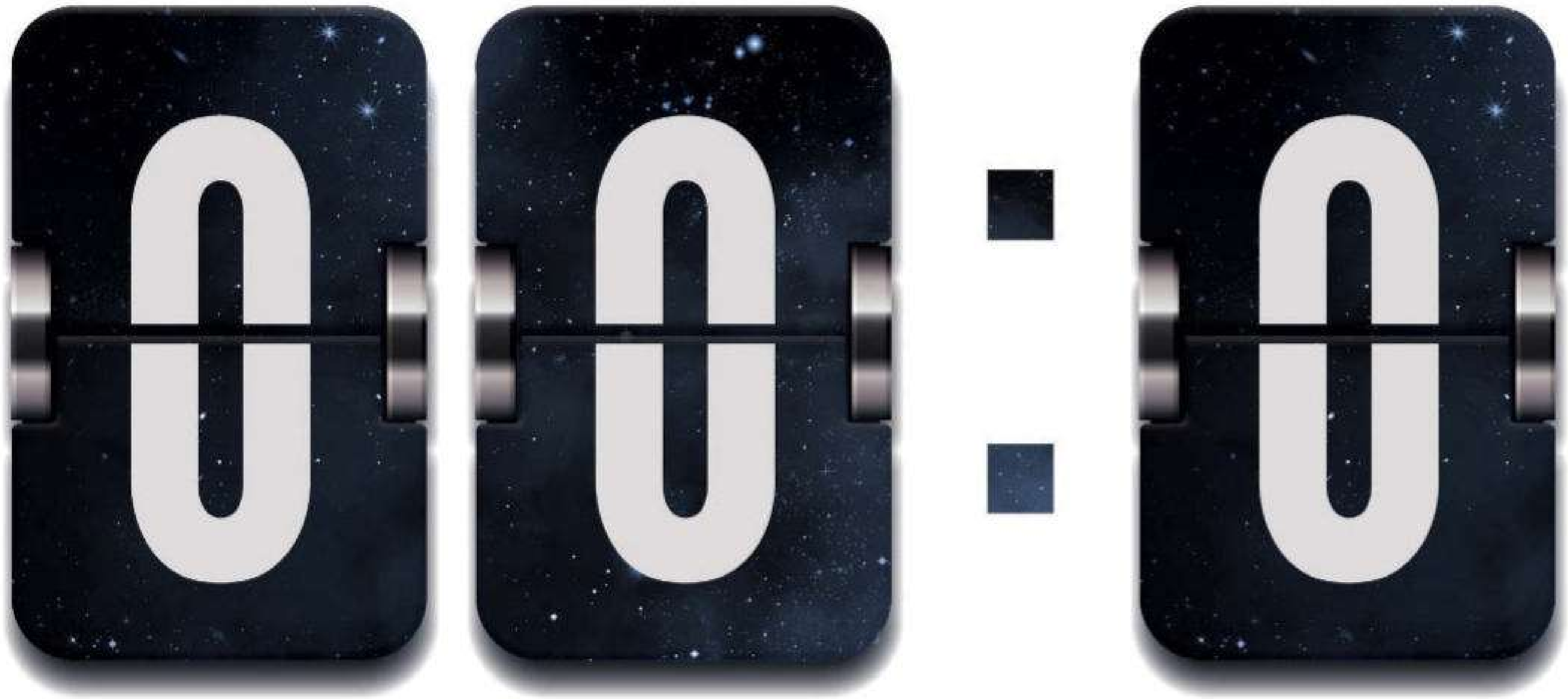

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The universe's first second

Elusive particles released just after the big bang could paint a never-before-seen picture of the newborn cosmos. Physicist **Martin Bauer** has a plan to finally snare them

AN INSTANT after the big bang, a vast shower of particles was released into the cosmos. Ever since, they have been flooding through space, carrying with them secrets from the dawn of time. How we would love to capture one – but these messengers are as elusive as they come. They pass clean through matter: 100 trillion of them are streaming through your body every second and you never notice.

These ghostly things are neutrinos, elementary particles that we know exist but that are exceedingly difficult to detect. There are experiments around the world that can capture neutrinos released from the sun, in vast traps buried more than a kilometre underground, for instance. Yet neutrinos released just after the big bang have far less energy and have so far proved impossible to detect at all.

A fabulous prize awaits if we could spot them, though. They would paint us an unprecedented picture of the universe in its very first moments, hundreds of thousands of years earlier than we have ever been able to see before. It would transform cosmology.

For decades, any plans to detect these

elusive particles have required technology beyond our wildest imagination. But now things have moved on and I have a suggestion for how we might just snare them. In the past, we have simply waited for neutrinos to come to us. Yet there may be a way of having our detectors race towards them.

Everything we observe today was once crammed into a much smaller space. When the universe was young, it consisted of a speck of extremely hot, dense plasma. Things were so cramped that subatomic particles constantly scattered off each other with such frequency and force that atoms couldn't form without being immediately broken apart again. This primordial plasma was completely opaque. Photons, or particles of light, simply couldn't travel very far without being absorbed or scattering off another particle.

As the universe kept expanding and the plasma cooled, it became less dense and so less likely for photons to get scattered or absorbed by other particles. This continued until a key moment was reached, 380,000 years after the big bang, when the photons could finally escape. Now, light could travel unobstructed through the cosmos. We can still see the photons released at that instant today: they form the universe's oldest light, which we call the cosmic microwave background (CMB).

The CMB was discovered by accident. In 1964, when Robert Wilson and Arno Penzias set up their now-famous horn antenna to detect radio waves from early balloon satellites, the whole idea of the big bang was very much an open question. Even after accounting for all possible sources of noise, the pair heard a puzzling continuous background signal coming from all directions. It was there day and night. They eventually realised they were detecting the CMB and this was our first glimpse of the universe's first light.

Cosmic dawn

Since then, we have measured the cosmic background photons with high precision, and we continue to do so. This gives us a picture of the universe when it was 380,000 years old – a mere baby compared with the 13.8 billion years it is now. We see dense patches that later developed into galaxies, and patterns that tell us about the relative amounts of radiation, matter and dark matter in the early universe.

The CMB is the oldest light we have seen – and the oldest we ever will see. But there is another, untapped source of information about the early universe out there that could help us peer much further back in time.

Though neutrinos are decidedly strange, we have known about them for a long time. They were first hypothesised in 1930 and detected in experiments in 1956. They are created all the time as a consequence of radioactivity – even an ordinary banana produces streams of neutrinos as the potassium atoms inside it decay. However, neutrinos are extremely light and barely ever interact with anything else.

Because of their antisocial behaviour, neutrinos could move around unobstructed much earlier on in the early universe compared with light. While photons were constantly bumping into other particles, neutrinos could stream freely through that hot, dense plasma. The big bang theory predicts that neutrinos created in the first second of the universe would have immediately been able to escape the fog and they would still be flowing through the cosmos today. Rather than the CMB, ›

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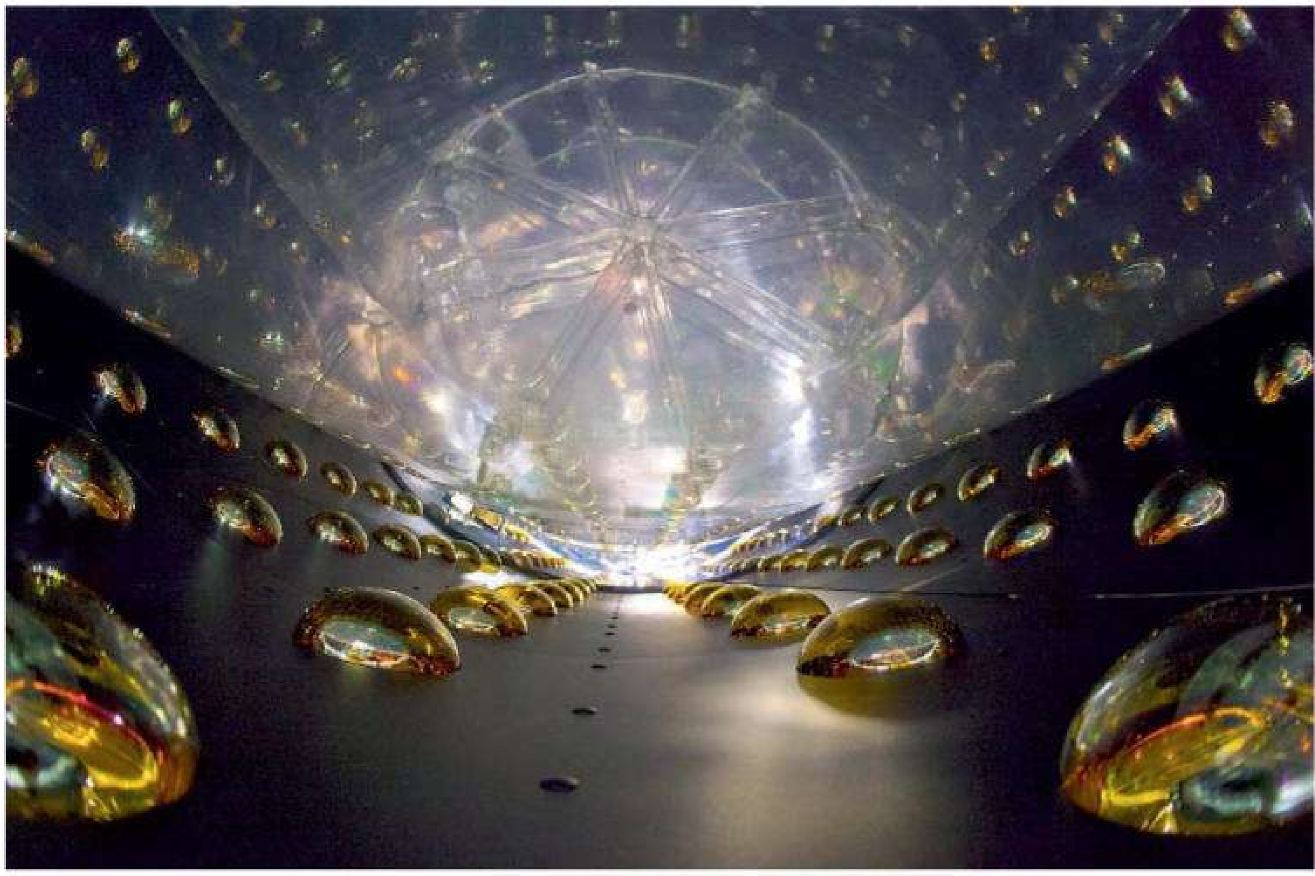
we call this the CNB, or the cosmic neutrino background.

Discovering the CNB would be huge. It would provide a completely new way of seeing how the universe developed. To understand why, we need to get to know a bit more about neutrinos and how they travel. The key difference between photons and neutrinos is that the former are massless, while the latter do have mass, albeit a very tiny one. In fact, neutrinos come in three different types, each of which has a slightly different mass. Because of this, background neutrinos would end up travelling at a range of speeds, all roughly 1000 times slower than light, as they stream towards us.


NATURE AND SCIENCE/ALAMY

An early neutrino detector (above right) was built in the Homestake gold mine, South Dakota. Daya Bay Neutrino Experiment in China (above) is a more modern facility that aims to study the properties of these ghostly particles

The universe in colour

As the cosmic neutrinos speed through the universe, their course is bent by the gravitational pull of huge objects like galaxies they pass, an effect called gravitational lensing. This happens with light too, but because all light travels at the same speed, its path is bent in a way that depends on how massive the object was at one particular time, when the light ray zipped past. In contrast, cosmic neutrinos are travelling through space at different speeds and therefore they pass those huge objects at different times. This means that, if we could scan the sky for cosmic neutrinos, we could use them to glimpse the large-scale structure of the universe at different times. Think of it like this: if the CMB showed us a black-and-white photo of the early universe, cosmic neutrinos would produce a 3D movie in full colour.

Though we have never seen them, we have good reason to think cosmic neutrinos are there: their existence is as inevitable a consequence of the big bang as the CMB. And if they aren't around, finding out would be an incredible discovery. It would be a direct contradiction of the established model of the big bang – a contradiction that would require exciting new physics to explain it. We simply must try to detect them.

But it won't be easy. Although experiments have detected some types of higher energy neutrino, such as those produced by the sun, the energy of cosmic neutrinos would be a billion times smaller than the lowest energy neutrino from other sources that we have observed so far, making them inestimably hard to catch.

The earliest idea to find them was proposed in 1962 by the late Nobel-winning physicist Steven Weinberg. He was inspired by a technology that was used to first discover non-background neutrinos in the 1950s and later used to detect solar neutrinos.

> **"Even an ordinary banana produces streams of neutrinos"**

It turns out that, if a neutrino hits an atom, it can be captured, imparting enough energy to transform one of the atom's constituent particles, a proton, into another, a neutron. The chemical elements are defined by how many protons they have, so if this process happens, it produces a different chemical element – that is detectable and is a surefire sign that a neutrino was involved.

In 1970, physicists Raymond Davis Jr. and John Bahcall set out to find these signs by filling a tank with 380,000 litres of a liquid rich in chlorine. If a neutrino hit one of the chlorine atoms, it would turn it into an atom of argon. The only problem was that incoming cosmic rays – high-energy particles from space – could do the same thing. So the pair placed their tank in the decommissioned Homestake gold mine in South Dakota, almost 1500 metres underground. While cosmic rays were screened out, neutrinos sped through the ground and turned some of the buried chlorine into argon. By counting how many, Davis and Bahcall were able to work out the rate of flow of solar neutrinos – and net themselves the Nobel prize in physics in 2002.

BROOKHAVEN NATIONAL LABORATORY/SCIENCE PHOTO LIBRARY

Weinberg had a similar strategy in mind to discover cosmic neutrinos. But because they have such low energies, they simply aren't powerful enough to convert protons into neutrons in any kind of stable atom. Because of this, Weinberg turned to tritium, a radioactive version of hydrogen with two neutrons and one proton. Tritium is unstable, which means it decays naturally by converting one of its neutrons into a proton, spitting out an electron at the same time. The electron is released with a known energy. But if a tritium nucleus absorbs a cosmic neutrino before it decays, the energy of the electron it spits out can exceed what would be expected because the neutrino puts in some extra oomph. Weinberg reasoned that, if we could measure the electron energy with extreme precision and we detected unusually energetic electrons being produced by tritium decay, we would have discovered the cosmic neutrino background.

All this would be extraordinarily challenging to pull off. Using 100 grams of tritium would yield just four neutrino absorptions – and so four unusually energetic electrons – per year. That is minuscule compared with the release of 100 trillion lower energy electrons per second via natural decay. Spotting those four rogue electrons would be nigh impossible and, currently, the technology is limited on all fronts. Yet there is an active international research collaboration called PTOLEMY that aims to build a prototype of such a detector.

In the meantime, other physicists have proposed different ways of detecting cosmic neutrinos – some more likely to prove successful than others. In 1974, the late physicist Reuven Opher first suggested measuring the pressure that cosmic neutrinos exert on a special probe called a torsion pendulum. But since neutrinos barely interact with matter, this pressure would be tiny and we would need to improve the sensitivity of the best measurements of such a set-up by a factor of a billion to have a hope of success.

Then, there is the idea proposed by physicist Thomas Weiler in 1984, which involves counting cosmic rays as a different proxy for cosmic neutrinos. It turns out that high energy neutrinos can hit the atmosphere and produce a cosmic ray that then shoots down to Earth. We can reliably detect these cosmic rays. But there is a rare process in which a cosmic neutrino hits one of the high energy neutrinos and the two annihilate, meaning that fewer cosmic rays are created. So, in theory, we could determine the presence of the cosmic neutrinos by a dip in the rate of incoming cosmic rays. If this sounds like a long shot, it certainly is. We would need to run a detector for centuries before we managed to see the dip.

In short, all the ideas for snaring the CNB have rather serious difficulties. Which is why, recently, my PhD student Jack Shergold and I have come up with an alternative possible route to discovery. It is based on overcoming the primary obstacle of each proposed experiment: that cosmic neutrinos carry so incredibly little energy.

A harder crash

In normal neutrino detectors, huge vats of atoms are sitting still waiting for relatively fast-moving solar neutrinos to strike them. When it comes to cosmic neutrinos, they are moving much slower and have less energy, so the collisions are harder to detect. We can't do anything about the neutrinos. But what about the target atoms? Could we somehow accelerate them so that when they collide with cosmic neutrinos the overall crash is harder?

Accelerating atoms is difficult, since they are electrically neutral. This means they aren't influenced by the strong electromagnetic fields that are used in accelerators such as those at CERN to get charged particles, like protons, to near the speed of light. Yet there is a trick we can pull: if we strip off some of an atom's outer electrons, this produces a charged version of the atom called an ion. This can be accelerated using common technology and the fact that an electron is gone makes little difference to any interactions with neutrinos.

Last year, Shergold and I considered a situation in which we use an accelerator to speed up a large number of ions. Cosmic background neutrinos would flood through the accelerator all the time, in the same way that they pass through your body. We calculated that it would be possible to design a set-up like this so that we have collisions with enough energy to detect cosmic neutrinos.

If we employed the chlorine-to-argon transition used in the Homestake experiment, that would require an accelerator with an energy a million times greater than that of the Large Hadron Collider (LHC). This is, of course, a huge problem.

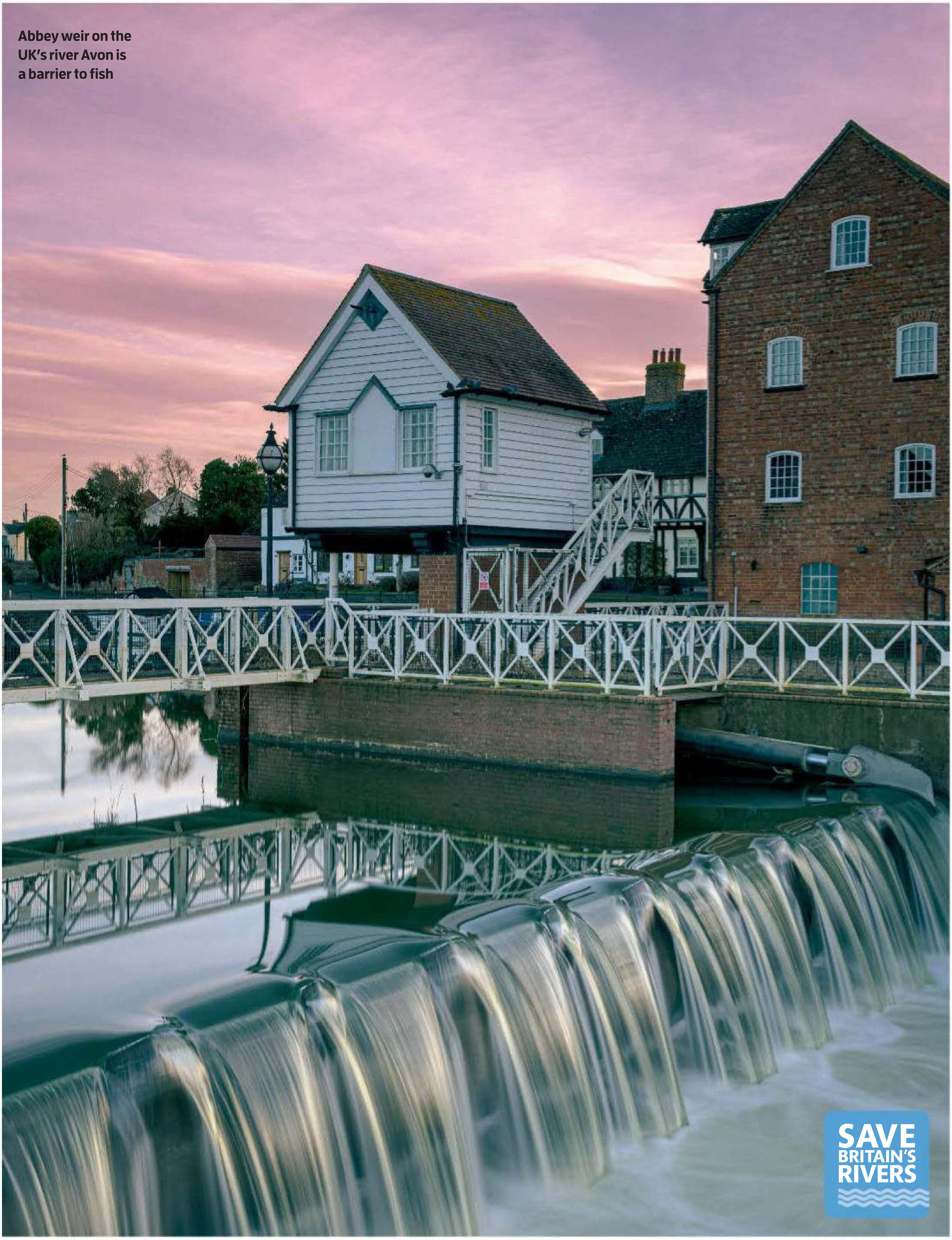
But there are other kinds of ions that might work. For example, we could accelerate helium ions which, if struck by a neutrino, would transform into tritium. To get this working, we would need an accelerator only about 100 times more powerful than the LHC. Not a piece of cake, but not out of the question either. Another challenge would be to accelerate the large numbers of ions needed; it would be many more than typically used in particle-smashing experiments.

We are still at an early stage with the research in this area. The trick will be to find ions that will interact with neutrinos at as low an energy as possible. That way, we would need fewer of them – perhaps many orders of magnitude fewer.

Finding ions with the correct properties to make this a reality may not be any easier than realising Weinberg's experiment. Yet the challenge is different and much less well explored, which makes it worth investigating.

Some of the biggest discoveries in physics – from the Higgs boson to gravitational waves – were decades in the making. It will likewise take time to corner the first cosmic neutrinos. But we could be one breakthrough away from finding the ghostly particles that carry the universe's earliest secrets. ∎

Martin Bauer is a physicist at Durham University in the UK



Abbey weir on the UK's river Avon is a barrier to fish

MARGARET CLAVELL/ALAMY

SAVE BRITAIN'S RIVERS

Go with the flow

Taming rivers to suit our needs has had some disastrous environmental consequences. Can we reverse the damage, asks **Graham Lawton**

WHEN I visited the river Derwent in Yorkshire in March, the landscape wasn't as I remembered it from my youth. Normally, the floodplains would be inundated with water and the whole river system feel like a miniature recreation of the vast glacial lake that covered this part of northern England after the ice sheets last retreated. But an unusually dry February meant that floodwater was lacking. On the upside, it allowed me to approach the river across an area of grassland called Wheldrake Ings, which is a haven for rare plants.

The word "ings" derives from the Old Norse word for a water meadow. This was once Danelaw, an area administered by Vikings from Jorvik (now York), and their language is still etched on the landscape. In fact, this stretch of the Derwent looks much as it would have when Danish berserkers invaded in the late 9th century. That is a far cry from most UK rivers. Many have been heavily modified to suit our needs: blocked by dams and other barriers, corralled, straightened, widened or narrowed, disconnected from floodplains, sucked dry for drinking water and encroached on by housing estates and business premises. A river with no such obstructions or canalisation is called "free flowing". Just 3 per cent of rivers in the UK fit that description.

This is an environmental disaster. Free-flowing rivers are a valuable part of healthy landscapes and ecosystems. They provide various ecological benefits, from carrying sediment and purifying water to allowing fish to migrate. How can we reverse the damage we have done and help our rivers run free again?

Humanity has been trying to tame rivers for millennia and, today, the results are clear to see. In 2019, when a team at McGill University in Montreal, Canada, and their colleagues produced the first global map of free-flowing rivers, they found that only about a quarter of very long rivers – those in excess of 1000 kilometres – are unobstructed along their entire length. These are almost all in remote regions of the Arctic and the Amazon and Congo basins. More encouragingly, 80 per cent of medium rivers (between 100 and 500 kilometres) and 97 per cent of short rivers (between 10 and 100 kilometres) were classified as free flowing. However, the researchers warned that those numbers are probably vastly inflated because their analysis excluded small barriers. This is especially true of highly developed regions in Europe and North America; the overwhelming majority of truly free-flowing rivers are in remote areas.

More recently, a European Union project called Amber (Adaptive Management of Barriers in European Rivers) concluded that 3 per cent of UK rivers flow unobstructed. That is very low by global standards, but perhaps not surprising given the long history of river modification in this small, crowded country. One of the earliest approaches was what is now called channelisation, which entails raising riverbanks, deepening the channel, consolidating separate streams known as braids and sometimes straightening out meanders. Historically, this had two main purposes, according to Susanne Muhar at the University of Natural Resources and Life Sciences in Vienna, Austria. The first, and foremost, was to improve navigability for shipping, which is why it is also called canalisation. The second was to control flooding by segregating a river from its floodplains, with the knock-on benefit of draining floodplains, which could then be used for agriculture and settlement.

Until the industrial revolution, channelisation in the UK was quite benign, but the advent of steam power upped the ante considerably, says Muhar. River navigation came under intense competition from the railways and responded by fighting fire with fire: steam-powered watercraft became larger and there were extensive "improvements" to rivers. This process continued throughout the 20th century, compounded by the fact that channelisation was also employed to speed up river flow to help flush away industrial effluents.

Shipping channels

Similar pressures were changing the course of rivers in other industrialising countries. Much of the early research on the detrimental ecological effects of channelisation was done in the US. It wasn't until 1983 that geographers made the first such survey of rivers in England and Wales. They found that, in the previous half century, 8500 of around 35,000 kilometres of the main rivers had been subjected to major channelisation. (This was a much higher proportion than in the US, which had a "channelisation density" of 0.003 kilometres per square kilometre, compared with 0.06 in England and Wales.) Most of the rest was managed to some extent, including vegetation cutting and the removal of submerged ridges and banks to smooth out the flow.

Soon after, the Royal Geographical Society in London published a series of articles on problems associated with river channelisation. It concluded that the main

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PAUL GROVER/ALAMY

impacts are twofold: on the river system itself and on the wildlife around it.

Unsurprisingly, the physical characteristics of a channelised river change dramatically; that is the whole point. The increased flow rate can cause a river to gouge ever deeper, further estranging it from its floodplains. This has knock-on effects downstream. If and when the river re-enters a non-channelised section, the flow rate decreases and masses of sediment are deposited, often requiring the next section to be channelised in a domino effect. This is what happened to the Danube in Austria, which is now completely channelised, according to Muhar. If a river has been channelised to reduce flooding, this often merely displaces the problem downstream, again inviting further channelisation. Then there is “retrograde erosion”, where the pull of the channelised section increases flow rates upstream, altering the course and depth of a river’s upper reaches and gouging out yet more sediment.

The negative effects on biodiversity result principally from homogenisation of the riverine habitat. Flow rates become more uniform, depriving aquatic species of their preferred water velocity. “You change the habitat structure,” says Ulrika Åberg at the International Union for Conservation of Nature in Gland, Switzerland. “You often get a very monotonous system that doesn’t have a large variety of riffles [shallow, turbulent zones] and pools and other morphological features that are important for the ecosystem.” Meanwhile, the removal of bankside vegetation can alter the water temperature and reduce the amount of nutrients falling in.

Fabulous floodplains

The value of a non-channelised river can be seen with the Derwent. The river itself supports many rare ecosystems and species, such as river lampreys and mats of vegetation that provide food and shelter for fish. And the floodplains are so important ecologically that much of Wheldrake Ings is a national nature reserve. Annual floods deposit masses of nutrient-rich sediment onto the ings, maintaining a rare, protected habitat called MG4 grassland. When I was there, it looked like an unremarkable field of turf. But this becomes a riotous flower meadow and, in late summer, will be a valuable hay crop, prized by specialist livestock farmers. “It’s a certain mix of plants and grasses,” says Craig Ralston at Natural England, which manages the reserve. “This area contains a significant proportion of [MG4 grassland], probably a third of the global resource, because it is globally confined to England and Wales.” The flooded ings also support an internationally significant influx of migrating waterfowl, with around 40,000 overwintering shovelers, teals, wigeons, Bewick’s swans, ruffs and golden plovers.

> **“A much higher proportion of main rivers have been channelised in the UK than in the US”**

MICHELE FALZONE/ALAMY

Glen Canyon on the Colorado river was once rich in wildlife

Nevertheless, not all is free flowing on the Derwent. Although largely unchannelised, except in its lowest reaches, it does have barriers that alter its flow and prevent the natural movement of sediment and animals. There are four old weirs upstream of Wheldrake, and downstream there is a large, modern lock-and-sluice system used to control water levels to enable the extraction of drinking water. There is also a tidal barrier at the river’s confluence with the Ouse at Barmby on the Marsh, which prevents brackish water entering and tainting the drinking water. “Human-induced changes in hydraulic conditions” is one of the major threats to the Derwent, according to the EU’s Natura 2000 programme, which has designated part of it a special protection area.

Again though, the Derwent has far fewer barriers than many other UK rivers. In 2020, a team led by Carlos Garcia de Leaniz at Swansea University in the UK published an inventory of these obstacles across Europe: dams, weirs, sluices, culverts, fords, ramps and others, including small ones that had previously been overlooked. In the UK, they recorded 23,719 barriers on more than 68,000 kilometres of river. That suggests the UK has nearly 50,000 barriers in total, or about 0.7 per kilometre of river. The average for western Europe is 2.7, but that is heavily skewed by the Netherlands, which has 19.4 per kilometre.

One major problem with barriers is that they

> **“Rivers in the UK have nearly 50,000 barriers in total, or about 0.7 per kilometre”**

JOHN MORRISON/ALAMY

The Thames Barrier (left) helps prevent flooding, the very thing that makes Wheldrake Ings (above) biodiverse

impede fish, especially migratory ones such as eels and lampreys, which swim far up and down rivers to complete their life cycles. On the Derwent, river lampreys are only found downstream of the lock, suggesting they can’t get through it. There are fish passes but they are “probably not very successful”, says Ralston. Critically endangered European eels also get stuck behind or in front of barriers. They migrate from the Sargasso Sea in the Atlantic deep up rivers across Europe and North Africa to mature, then return to the sea to breed many years later. River barriers are one factor in their precipitous 90 per cent decline since the 1980s, says eel expert Jack Wootton at the University of Hull, UK.

Removing obstacles

Barriers stop the natural movement of sediments too. “They get trapped, which means that the river downstream gets starved of sediment,” says Åberg, “When the river doesn’t get replenished by new sediment, the force of the water starts digging down into the bottom, so you can get a very strong incision.”

The obvious solution is to remove barriers where possible. “Often no one really knows what a weir was for,” says Wootton. “That isn’t the case for all weirs, dams and sluice gates, but for a significant amount of them, nobody has any want or need any more.” A key obstacle to getting rid of them is economic. “Money is an issue. You’re talking about hundreds of thousands of pounds, potentially, [for a stretch of river],” he says. Another issue is that removing seemingly redundant structures may have unintended consequences. Take the Derwent again. In the 1950s, engineers built up some of the riverbanks around Wheldrake to reduce the frequency of flooding. It would seem logical to raze them now, says Ralston. But climate change means that more water flows into the Derwent than before, so their removal might threaten the ings with excessive flooding. “That’s a really difficult one to solve,” he says.

Other barriers simply can’t be removed. These include hydropower dams and constructions designated as industrial heritage. Even where historic barriers aren’t protected, it may be impossible to get rid of them because of their settings. For example, says Ralston, a few years ago, Natural England was involved in a project to see whether it was feasible to remove a weir built in the 1800s on the Derwent at Howsham to serve a now-demolished watermill. As a trial, the water level of the millpond was lowered. This caused the water table to drop, leading to subsidence damage to the nearby ruins of Kirkham Priory, a grade I-listed medieval building, and the plan had to be shelved.

Where barriers can’t be removed, fish passes may at least help rescue biodiversity. They have been installed at dams for more than a century and are usually one of three types: a slippery slope, a ladder or an elevator. Slopes are water slides for fish; ladders are a series of small pools of increasing elevation to enable fish to jump a barrier in bite-sized chunks; elevators are holding tanks that accumulate fish and periodically hoist them over. “How successful they are is open to debate,” says Ralston. One problem is that they can be quite selective in the species they help. “A lot of them are very specific, usually focused on salmonids,” says Wootton.

Fish-pass technology is quite rudimentary and has barely advanced in a century, but now things are improving. A Seattle company called Whooshh Innovations is designing high-tech fish passages such as the Lampway, a water-filled Archimedes screw that transports lampreys over otherwise-insurmountable barriers. Some of these systems automatically record how many fish pass through so biologists can monitor populations. Other innovative solutions aren’t so high-tech. The Lough Neagh Fisherman’s Co-operative Society in Northern Ireland has perfected a pass called an eel rope. “It’s essentially a long, sausage-shaped bundle of straw that you drape over the top of a river barrier and it creates a climbing structure that eels can work their way up and over,” says Wootton. Each sausage costs peanuts. “I truly believe in 10 years, we will be looking at very, very different fish passes,” he says.

This is all well and good, but Ralston points out that fish passes don’t address the wider issue of water quality due to sedimentation around barriers. Only removing the obstacles will do that. Even then, remediation isn’t always possible. “If a dam is very large and has been in place for a very long time, it creates irreversible impacts,” says Åberg. Reversing the worst effects of channelisation may also be impossible. In many cases, the river has gouged a bed several metres lower than where it started, making it hard to reconnect to its floodplain. Besides, those floodplains are now often covered in houses and businesses that need flood protection.

One key lesson from all this is to value our remaining free-flowing rivers, because undoing the damage isn’t going to be cheap or easy. But the good news is that, if we embrace the challenge, we will have a surprising ally. What has been done can sometimes be undone simply by letting nature take its course, says Åberg. “Rivers can restore themselves if we just remove embankments and barriers and everything that constrains them.” ▮

Graham Lawton is a features writer at *New Scientist*

"People are being fed false information"

Ultra-processed foods are damaging our health in ways we are only just beginning to understand, says **Chris van Tulleken**. He tells Clare Wilson what we can do about the problem

FROM cocktail sausages to ready meals, ultra-processed food has long been suspected of being nutritionally inferior. Most dietary guidelines say this is because it tends to be high in fat, sugar and salt. But that is missing something vital, says doctor, academic and TV presenter Chris van Tulleken in his new book, *Ultra-Processed People: Why do we all eat stuff that isn't food... and why can't we stop?*

What really determines a meal's nutritional value, says van Tulleken, is how it is made: in the home or a factory. This idea puts a spotlight not on individual ingredients, but on how the way they have been processed, reformulated and cooked affects our health. The industrial techniques used to make many modern foods not only add unhealthy ingredients, but also change the way the foods themselves interact with our body, says van Tulleken – and with ultra-processed food now making up more than half of all food eaten in many Western countries, the consequences for much of the world's health are catastrophic. He tells *New Scientist* what we can do to turn this trend around.

Clare Wilson: Why is ultra-processed food worse than the food we cook from scratch at home?

Chris van Tulleken: The industrial processes involved in food manufacturing change its chemical and physical structure. They reduce food crops to their core constituents, such as high fructose corn syrup made from corn starch or hydrolysed vegetable protein from soya beans, which are then reformulated into substances that are highly palatable and calorific. These processes strip out fibre and micronutrients. Then ingredients are added that our bodies haven't evolved to cope with, such as artificial flavourings and emulsifiers. We have evolved to eat naturally arranged matrices of different chemical constituents and when you separate them into their molecular components and chemically modify them, they seem to interact with the body in a very different way. For instance, a study has shown that the body has a slower sugar and insulin response to eating an apple compared with apple juice and a raw apple smoothie.

This contradicts common advice to focus on fat, salt and sugar. How much evidence is there that processing is more important?

The epidemiological evidence (data from big groups of people) has piled up – we now have more than 100 really good-quality studies showing diets high in ultra-processed food go hand in hand with worse health, whether you're looking at mortality, cancer, inflammatory bowel disease, dementia, obesity, stroke and on and on. When you statistically adjust the results to take into account socioeconomic factors, and to take account of the fact that highly processed food has more sugar and fat and less fibre, the size of the effect remains the same. Most of the studies that link eating sugar, salt or fat to poor health outcomes don't make this same adjustment. There are also plausible biological mechanisms for all the different ways that this food might harm us. For instance, we know that emulsifiers harm the gut.

What are emulsifiers and why do they harm the gut?

Emulsifiers are a wide variety of chemicals that bond fat to water – like soap, which lets you wash oil off your hands. There is something about these artificial emulsifiers in food where they act a bit like detergents and scrub out your intestines. Our intestines are covered in a layer of mucus and in that are trillions of bacteria, which are intimately linked to health. Studies show that certain emulsifiers, like carboxymethyl cellulose, seem to increase the permeability of the gut barrier and increase the amount of bacteria that enter the bloodstream from the gut. They may also change the populations of bacteria that live in the gut, going from broadly health-promoting ones to health-limiting bacteria, and promote inflammation.

How about sweeteners?

Sweeteners are really intriguing because they exemplify the whole problem. The traditional way of thinking about nutrition is that sugar is harmful, it's a source of calories. It ought to be the case that if we replace sugar with zero-calorie sweeteners, we should see a pretty significant loss in weight. But at best, trials show that it has no effect. That should raise

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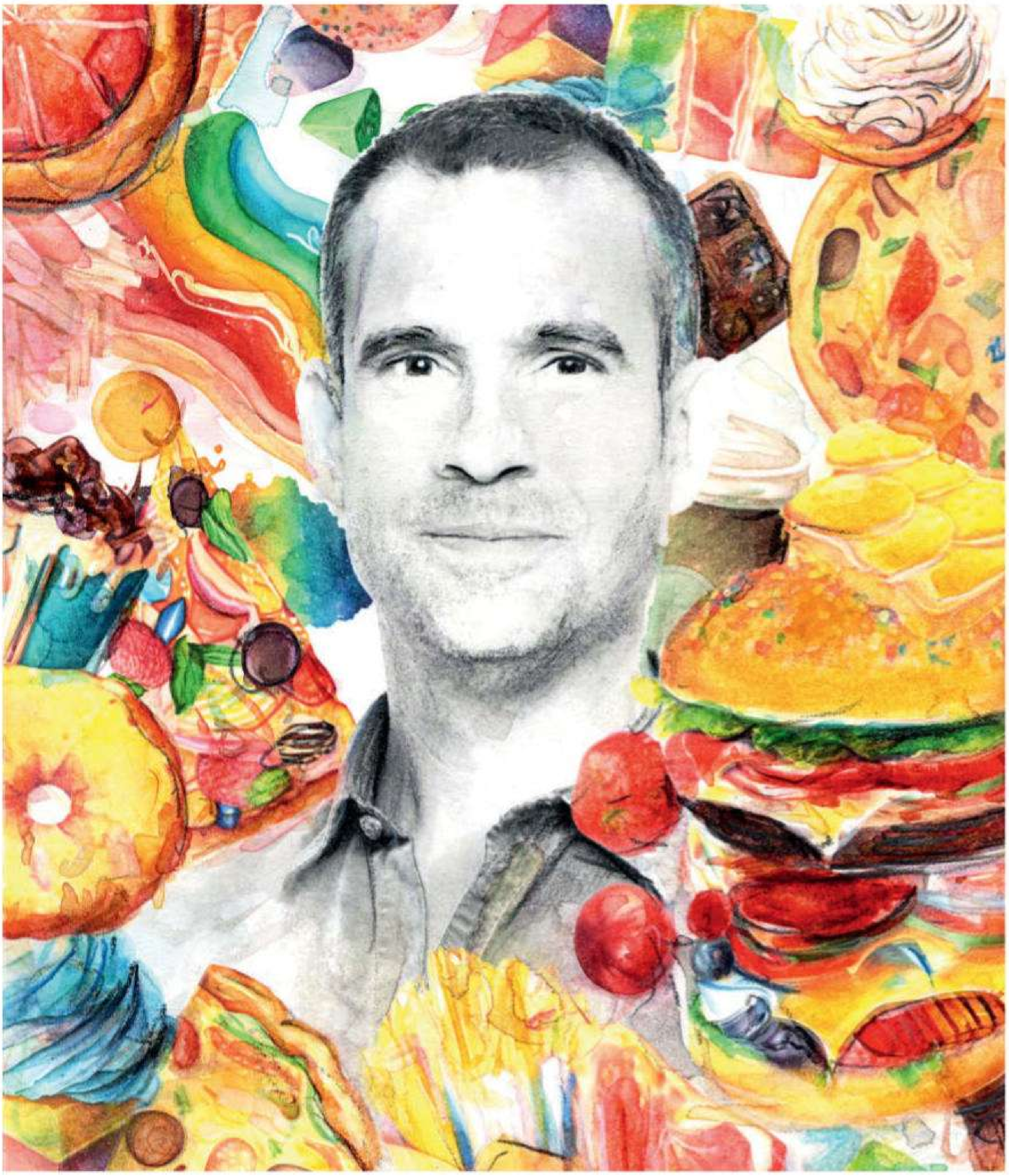

NABIL NEZZAR

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alarm bells. It may be the case that if you put a sweet taste in the mouth, that tells the body that sugar is on its way and you get insulin release. If the sugar never arrives, that insulin stimulates appetite.

We know that epidemiological and animal studies can mislead. Are your ideas supported by randomised clinical trials?
The strongest evidence comes from a small clinical trial of 20 people that was run in a very convincing way. Each person ate ultra-processed food for 14 days and then unprocessed food for 14 days, or vice versa. The meals contained the same amount of fat, salt, sugar and fibre and people could eat as much as they liked. Despite rating the foods as equally palatable, people ate many hundreds of calories more per day on the ultra-processed diet than they did on the unprocessed diet. And they put on weight exactly as you would predict in line with that excess calorie consumption. That was very persuasive.

> "Why must we have cartoon characters like a monkey on a cereal box?"

Isn't it premature to advise people to change their diet based on one small trial?
The argument doesn't hinge on that trial – it is just a cherry on the top. If we didn't have it, the epidemiological evidence is now sufficient to show causality. We only have epidemiological data to link smoking with cancer, and most scientists agree on that.

Why does most official dietary advice from around the world ignore whether food is highly processed or made from scratch?
There are people who are unpersuaded, but this idea is becoming more widely accepted. I think we are fast approaching this being in Public Health England's dietary recommendations, which, at the moment, do not mention processing. Advice to avoid ultra-processed food is in French national dietary guidance and Canadian guidance, as well as some other countries, such as Brazil and Chile. It is mainly accepted in countries where food policy-makers have a less close relationship with the food industry.

Which food is which?

WHOLE FOODS
Foods that haven't been processed or had artificial ingredients added. In reality, most foods undergo some degree of processing, such as washing or boiling, so whole foods often include minimally processed foods such as wholegrain pasta or frozen peas.

PROCESSED FOODS
These are foods that have been changed from their natural state, for instance by being packaged, pasteurised or dehydrated. It also includes foods that have added preservatives, nutrients, flavours, salts, sugars or fats.

ULTRA-PROCESSED FOODS
There is no agreed definition of what makes a food "ultra-processed", but nutritionists tend to apply the term to foods that are the result of intensive manufacturing processes. It includes foods that have added sugars, fats and salts, but they also often have added ingredients taken from other foods such as high fructose corn syrup, maltodextrin, gluten and hydrogenated oils.

MARTIN PARR/MAGNUM PHOTOS

What is the nature of the relationship between some food policymakers and the food industry?
In the UK, when it comes to food policy, some of our most influential charities are partly funded by companies that make income from ultra-processed food. And as much as the money, there's a cultural problem. Until we start to see the companies that make ultra-processed food a little bit more like the tobacco industry – and regulate them as such – we're not going to make progress.

Isn't that demonising the food industry, to compare it to tobacco companies?
You can't treat food exactly like tobacco, but you can learn a lot of lessons about how you treat food companies from tobacco control. I do want to acknowledge that this is the only affordable, accessible foods that many families can buy to feed their children. I wouldn't tax this, I wouldn't ban it. And I would be conscious that any policy brought in would need to minimise stigma.

Labelling ultra-processed foods (left) more negatively could help people make healthier food choices. Above: vegan food has a reputation for being healthy, but can be ultra-processed

KATHARINA BRANDT/ALAMY

Aren't you increasing stigma when you say in your book's subtitle that ultra-processed food isn't actually food?
The forum in which you say something is crucial. In *New Scientist*, I'm happy to say it may be a useful mental trick to think of these products as not food, but as a soundbite in a live interview, that idea risks generating stigma and weight shame. The subtitle of my book – "Why do we all eat stuff that isn't food and why can't we stop?" – is trying to locate the problem in the food, not in the person.

Is it unrealistic to expect people on lower incomes, working long hours, to make meals from scratch?
People should have the choice. At the moment, they don't have choice or opportunity because they're fed false information and they are unable to buy healthy food, due to time and money. Rich people eat different food to poor people. If all we did was fix the problem of poverty in the UK, that could solve more than 50 per cent of obesity.

Fixing poverty seems a tall order.
Of course, but that's not what I'm proposing. Number one, you point out that there is early evidence showing that ultra-processed foods are linked with poor health. And I would put that in national nutrition guidance. That can sit alongside fat, salt and sugar, as those things are almost certainly harmful, too. Number two is marketing restrictions. Why must we have cartoon characters like a monkey on a cereal box? Number three is to improve institutional food. Schools, hospitals, prisons – all have to make available unprocessed food. Then we need to label whole foods positively (see "Which food is which?", left). Finally, we need to label packs of ultra-processed food somewhat negatively. At some point, we have to figure out a way of defining ultra-processed food and that is a real challenge. But there are lots of shorthand ways. If you just define it as food with an artificial emulsifier, a non-nutritive sweetener or high fat, salt and sugar, that wraps up more than 90 per cent of the ultra-processed foods.

Would you accept the modern food industry has some benefits, such as in reducing hunger? In your book, you describe the arrival of obesity and diabetes in Brazil as the diet there became more westernised – but at the same time, life expectancy rose.
The reason people began living longer is because there was improved sanitation and hygiene and public health measures around things other than food, like smoking. The nutrition transition has definitely done a bit of good. You don't see nearly as much malnutrition in Brazil now. But diet-related disease is still causing people to die earlier than if they were eating less ultra-processed food. There are real benefits to our current food system. I think we can acknowledge progress, while still holding gently in our hands the idea that with that progress came some genuine problems. Like automobiles, the food system has brought incredible benefits to millions of people, while also bringing very significant harms to people and the planet.

How about the benefit of freeing people – often women – from having to cook from scratch several times a day?
Saying that our food system causes diet-related disease isn't the same as saying we should all go back to cooking for 5 hours a day and women should stay in the kitchen. The food industry uses arguments like these to paint people like me as regressive.

How often do you make homemade meals for your children?
Two or three nights a week I cook them something like a piece of salmon, a lamb chop or pasta bake. We do have ready meals two nights a week and we have takeaway probably one night a week. I want to be able to choose crappy food for my kids sometimes. I have no interest in a nanny state. I don't think it's for governments to tell people how to eat. I think it's to create an environment where good food is affordable, where people aren't saturated in bad food and where the bad food is clearly labelled. ▮

Clare Wilson is a reporter at *New Scientist*

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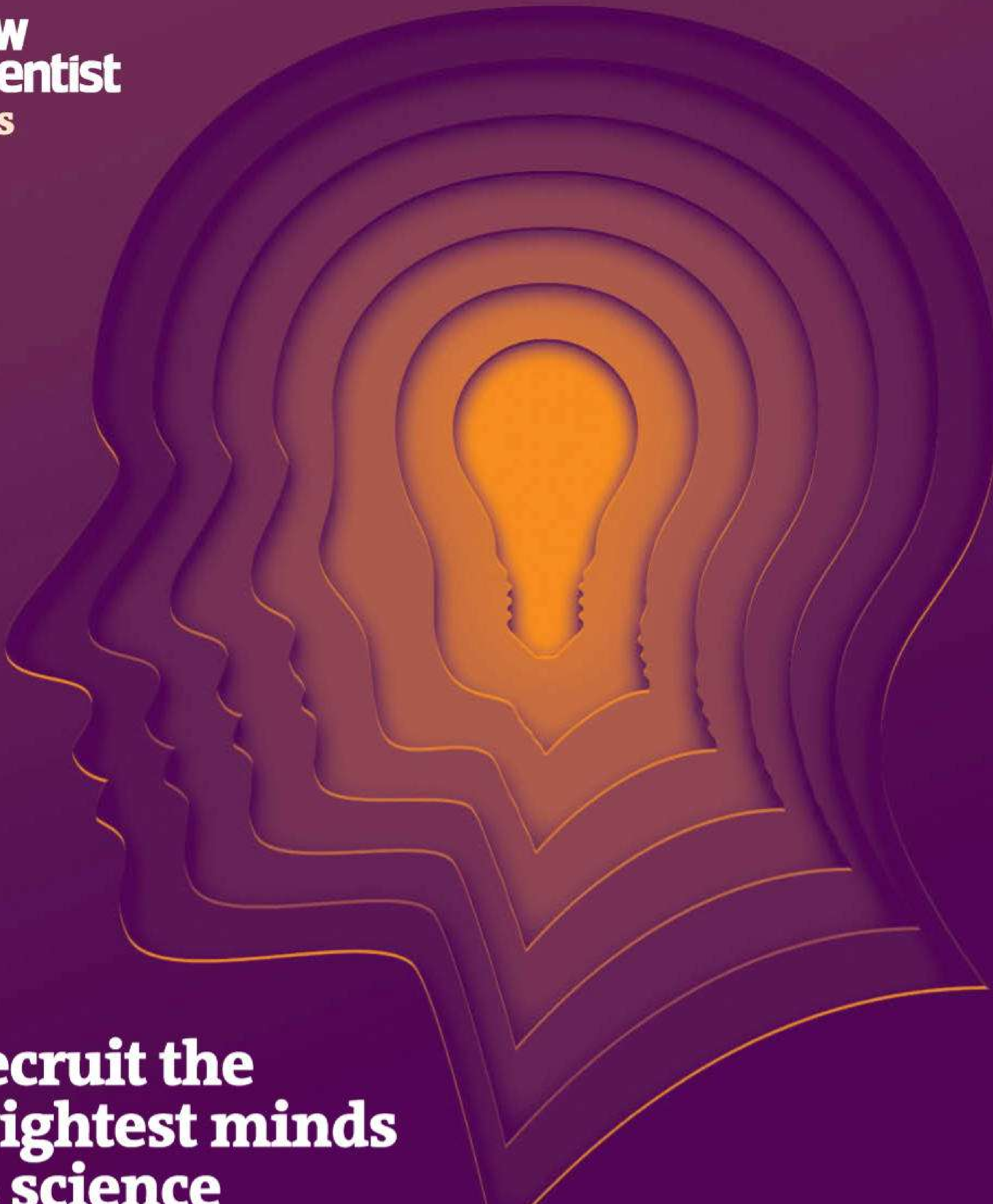

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Stargazing at home

Martian moment

Mars is currently passing through Gemini. Here's how to glimpse the planet and this lovely constellation, says **Abigail Beall**

Abigail Beall is a features editor at *New Scientist* and author of *The Art of Urban Astronomy* @abbybeall

What you need

Binoculars

Stargazing at home appears every four weeks. Share your stargazing successes with us on Twitter and Instagram @newscientist, using the hashtag #NewScientistStargazing

THIS column comes to you from a very different place – Australia, where I have been accompanying a New Scientist Discovery Tour to see the hybrid solar eclipse visible from the west of the country. I have had two weeks of stargazing here, getting to know the sky from a new perspective.

No matter where you live in the world, Mars is taking a little stroll through Gemini this week, so it is a great time to get to know this lovely constellation with its prominent twin stars, Castor and Pollux, and take a look at the Red Planet at the same time. Each night Mars will appear to be in a slightly different place, but throughout the end of April and until around 14 May, when it starts to move into Cancer, it will be near Castor and Pollux in the sky.

There are a few ways to find these stars, but one of the simplest is using the nearby constellation of Orion and its two brightest stars, Betelgeuse and Rigel. Betelgeuse is the red giant that makes up Orion's left shoulder. It appears in the top left of the constellation from the northern hemisphere, or in the bottom right as seen from the southern hemisphere. On the opposite side of Orion's belt sits Rigel, the blue-white supergiant. This makes up Orion's right foot – so again, it will be in the bottom right of the constellation in the northern hemisphere, but at the top left for those in the southern hemisphere.

ALAN DYER/VWPICS/ALAMY

To find Gemini, draw a line from Rigel to Betelgeuse, then keep that line going about the same distance again. You will see two bright stars: Castor and Pollux. If you are looking at the end of April or the beginning of May, a bright red "star" will appear near the twins – this is Mars. Take a look through binoculars to make the rusty hue of the planet a little clearer.

Those who live in the northern hemisphere might think of Orion as a northern constellation, since we are familiar with the upright figure of a mythical hunter that we ascribe to it there, but it is important all over the world.

During my trip to Australia, we were given a fascinating talk on Indigenous astronomy by Peter Swanton at Mount Stromlo Observatory near Canberra. He told us how the Kokatha people of Australia's Great Victoria Desert have a story about this constellation. They describe it as a hunter called Nyeeruna who tried to woo the seven sisters, or Yugarilya, the stars that make up what is also known as the Pleiades.

The sisters wanted nothing to do with him. Nyeeruna got angry and used fire magic – he lit his fire and it got brighter, and this caused the star we know as Betelgeuse to become more vivid and then dim. This story, which also talks about the dimming of the star Aldebaran as one of the sisters faced up to Nyeeruna to fight him off, represents one of the oldest human records of stars such as Betelgeuse that display variable brightness. ▮

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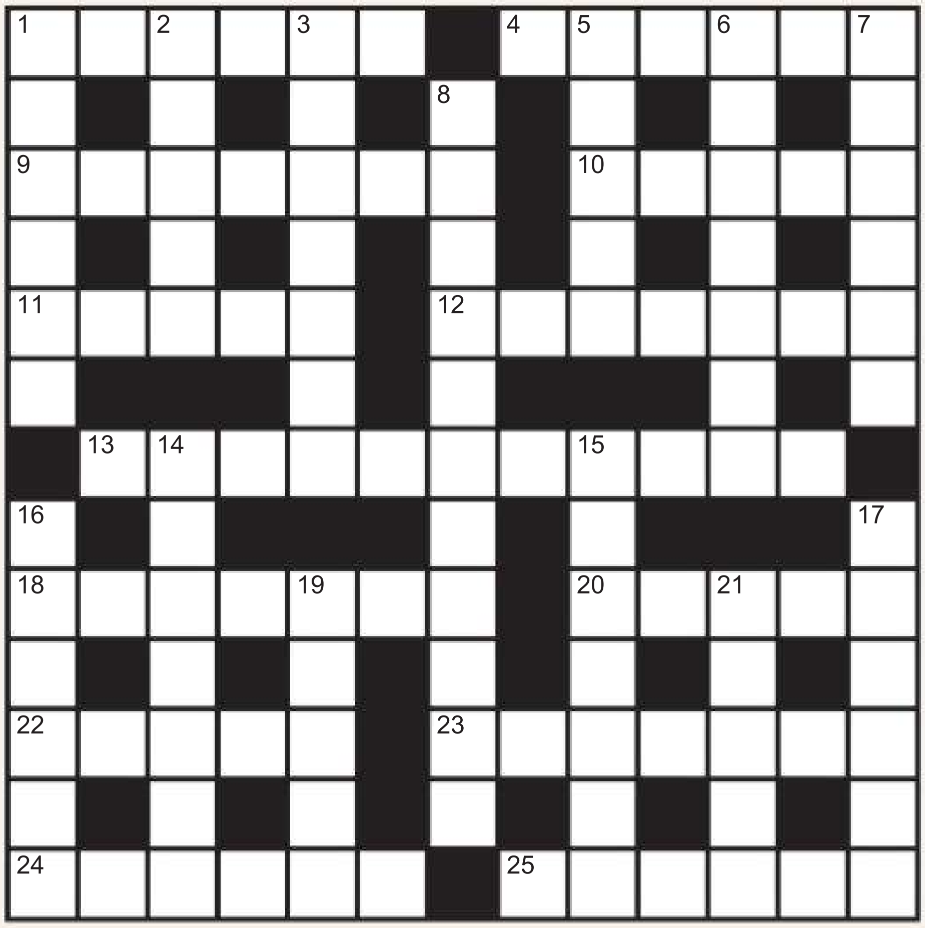
Cryptic crossword #108 *Set by Wingding*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Virus beginning to replicate inside poorly sheep (6)
4 Aggregate material with key metal (6)
9 Endurance inspires return with energy sapped (7)
10 Grain gets into doctor's appliance (5)
11 Bury penniless playwright (5)
12 Sulphur and phosphorus switched in attempt to rotate enzyme (7)
13 Lumber is best when there's no time to rebuild vessel (11)
18 Extremely reliable spy, one undergoing a change (7)
20 Discover source of a small amount (5)
22 Search engine captures old sound of spring (5)
23 Frantically racing after oxygen from living things (7)
24 Warm period beginning to manifest in early civilisation (6)
25 Faulty protein containing sulphur in a lot of cells (6)

DOWN

1 Bristly tail of melomys covered by cool papers (6)
2 Criticise bad astronomer? Not half! (5)
3 A pithy remark: "The horse rises over the swine" (7)
5 Daughter left in old donkey's coat, surprisingly (5)
6 Clip of classy baritone ascending, very deep (7)
7 Mathematician finally resting beneath Italian city (6)
8 Labour making wall around ancient city (11)
14 Fuel flowed under university, into upper mantle primarily (7)
15 Perhaps one or two misread greeting – not good! (7)
16 Birds mixed beer in empty glass (6)
17 Stimulant in meat is a source of light (6)
19 Predator took head off dog (5)
21 14 eaten by insects' relatives (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #199
set by Bethan Ackerley

1 An animal with the same name for both its genus and species, such as the red fox (*Vulpes vulpes*), is known as what?

2 What was the most powerful nuclear weapon ever tested by the US?

3 Where in the body would you find a Baker's cyst, also known as a popliteal cyst?

4 The comet Tempel 1 was visited by which NASA probe in 2005?

5 What is the most abundant gas in Earth's atmosphere?

Answers on page 55

Puzzle
set by Rob Eastaway

#219 The second red queen

"You know that debt you owe me?" says Svengali, rather menacingly. "I am prepared to write it off – but only if you have a bit of luck."

He takes out a regular pack of playing cards and gives them a thorough shuffle. "Now," he declares, "I am about to turn over all the cards one at a time, but first I want you to predict the position of the second red queen that I will turn over. If your guess is correct, I will write off your debt."

My odds aren't high. There are 52 cards in a pack. Only two of them are red queens – the queen of hearts and the queen of diamonds. And only one of those will be the second red queen to be turned over.

"I will give you one bit of advice," says Svengali, noting my pensiveness. "Don't choose the top card, because by definition that cannot be the second red queen – though it might be the first."

Which card position in the range 2 to 52 should I nominate for the second red queen? Or should I just pick a random number?

Solution next week

AFRICA STUDIO/SHUTTERSTOCK

What is the best way to load a dishwasher so the maximum number of items get clean?

This week's new questions

Stacking it up **Is there a correct way to fill a dishwasher to maximise capacity and cleanliness?** ***Conor McKeating**, Dublin, Ireland*

Lined up **Will there ever be a time when all the planets of our solar system line up in a row, one behind the other, as seen from Earth?** ***Sue McLennan**, Parkes, New South Wales, Australia*

Octopus tech

If an intelligent marine species like the octopus evolved to live on land, what is the likelihood it would develop technology?

Alex McDowell
London, UK
It probably would. Octopuses can already use tools.

To develop technology, dexterity is needed to manipulate objects. For this, humans have hands that were originally for tree climbing. Octopuses have tentacles that could serve the same purpose as our hands.

The first octopus-like species that evolved to live on land would be sluggish, because octopus bodies aren't really suited to being out of the water (though octopuses sometimes crawl onto land to move between rock pools at low tide).

This new species may overcome the problem by evolving a better body or higher intelligence, or a combination of the two. Human bodies aren't naturally suited to many of the environments we inhabit, but our intelligence allowed us to get round these problems by inventing tools and technologies.

"For octopuses, breeding probably takes priority over innovation, despite their impressive intelligence"

In science fiction, octopus-like creatures develop technology. For example, in *The War of the Worlds* by H. G. Wells, the invading Martians resemble octopuses and are technologically advanced.

Pat French
Telford, Shropshire, UK
Why would octopuses need to come ashore in order to develop technology?

A technology developed underwater would inevitably be very different from ours and would address different problems, but it could happen. That it hasn't might be due to the short life of octopuses: three to five years in the case of giant Pacific octopuses, during which time they breed only once before dying.

Breeding probably takes priority over innovation, despite their impressive intelligence.

Cold feet

If I go barefoot in snow, my feet soon hurt, yet my dog happily walks in freezing temperatures. What makes those paws so resistant to cold?

***@MayfairTweet**, via Twitter*
Dogs have several adaptations that help them to tolerate cold temperatures, including a layer of fur that provides insulation and helps retain body heat. However, the primary reason dogs can walk on snow and ice without experiencing pain or discomfort is that their paws are specially adapted for this purpose.

Dog paw pads are thicker and more resilient than the skin on human feet, providing a layer of insulation between the cold ground and the sensitive nerve endings in the paws. Additionally, dogs have a network of blood vessels in their paws that help regulate their temperature.

However, it is worth noting that, even with these adaptations, dogs can still experience cold-related problems, such as frostbite or hypothermia, if exposed to extreme temperatures for too long. It is important to monitor your dog's behaviour and limit its time outdoors when the weather is very cold.

***Ted Westmoreland**, via email*
Dog paws are protected from cold temperatures because the blood vessels they contain are arranged in a tightly knit rete mirabile – Latin for "wonderful net". This keeps the internal temperature of each paw closer to the ambient temperature, which reduces the rate of heat loss and so prevents frostbite injuries to the tissues in the paws of our canine friends.

The close proximity of the blood vessels in the rete mirable produces a "countercurrent exchange gradient" between the arteries, which carry warmer blood from the core, and the veins, which carry cooler blood in the opposite direction, returning it from the extremities.

This system is much more efficient in creating a consistent gradient for heat transfer along the length of the contact than a cocurrent exchange, where the fluids flow in the same direction and stop transferring heat when a point of equilibrium is reached.

The constant biological heat exchange of the countercurrent flow in this mesh of vessels reduces the temperature of the blood travelling to the paw. This means that heat loss from the paw is minimised, but the temperature is warm enough to avoid frostbite.

All aboard

What is the most efficient way to load passengers into an aircraft: randomly; in blocks; or the passengers in window seats first, followed by those in middle seats, then those in aisle seats? (cont'd)

Greg Blonder
Mechanical engineering department, Boston University, US
There is a mechanical engineering reason to board from the front.

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Tom Gauld
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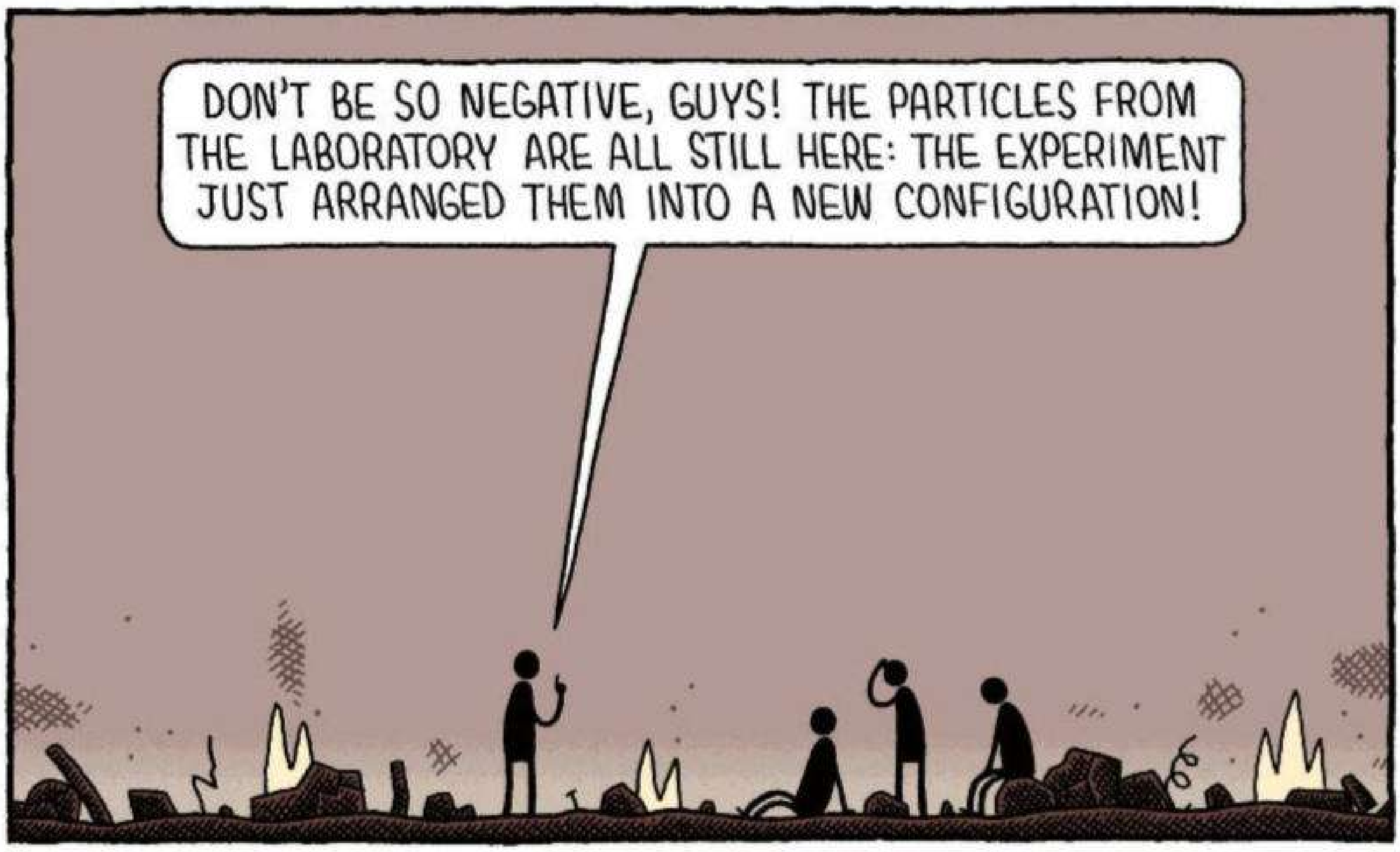

DON'T BE SO NEGATIVE, GUYS! THE PARTICLES FROM THE LABORATORY ARE ALL STILL HERE: THE EXPERIMENT JUST ARRANGED THEM INTO A NEW CONFIGURATION!

Depending on how far the tail section cantilevers beyond the rear wheels, the passengers' weight can cause the plane to seesaw down onto the ground.

Similar issues can occur when filling the cargo bay.

> **"There is a mechanical reason to board from the front of an aircraft: the passengers' weight can cause it to seesaw onto the ground"**

Rob Wallace
Paynesville, Victoria, Australia

It was good to read contributions on the perennial problem of aircraft boarding (11 February), especially the comment that the "Flying Carpet" method is claimed to be the quickest of all. *[Ed. – in this method, passengers assemble in groups in the corridor leading to the plane, where the floor is marked with a grid corresponding to their seat numbers. Passengers then board in this exact order.]*

It is true, it was the fastest of all methods tested during an independent series of trials conducted over a month at Pulkovo Airport in St Petersburg, Russia. Unlike other trials, these were conducted under real-world conditions at a commercial airport with normal scheduled flights and real passengers.

A significant finding was that placement of the Flying Carpet immediately after where boarding passes were checked was best. It enabled passengers to easily arrange themselves in row order before walking to the plane.

It was also easier for staff to manage and avoided the problem that plagues all other methods: the irresistible urge by many passengers to surge towards the gate when boarding commences, regardless of announcements.

Another significant finding was that small groups of 15 to 20 worked best. Not surprising really, as that is about the maximum number that can comfortably fit along the length of an aircraft aisle, with each having plenty of elbow room to stow their bags and get seated efficiently. Obviously, this requires more groups, but it was actually quicker overall than with fewer, larger groups, as the small groups follow each other in quick succession.

With a group arriving every 45 seconds, 10 groups of 15 people could get aboard the aircraft and seated with their baggage stowed within 9 minutes.

Other refinements were about to be tested in late 2019, but, alas, covid-19 intervened and the trials had to be abandoned. Disappointing, yet perhaps a blessing in disguise as it revealed another advantage of the Flying Carpet system – there is much less chance of infection transfer because the reduced mingling of passengers means less exposure to pathogens.

I am the inventor of the Flying Carpet system, but (regrettably) with no commercial involvement in airlines or aviation – I am just a retired design engineer who likes to solve problems. For more information, go to roundpegin.com. ▮

Answers

Quick quiz #199 *Answers*

1 A tautonym
2 Castle Bravo, which had a 15-megaton yield
3 The back of the knee
4 Deep Impact
5 Nitrogen

Quick crossword #131 *Answers*

ACROSS 1 Island, **4** Twenty, **9** Beam, **10** Willowherb, **11** Stereo, **12** Visceral, **13** Manganese, **15** True, **16** Axle, **17** Analgesia, **21** Physical, **22** Jaguar, **24** Virologist, **25** Iris, **26** Meeple, **27** Jet lag

DOWN 1 Inertia, **2** Lemur, **3** New moon, **5** Whoosh, **6** Nth degree, **7** Yardage, **8** Clive Sinclair, **14** Gallstone, **16** Atheism, **18** *La Jetée*, **19** Imaging, **20** School, **23** Grill

#218 Playground parity *Solution*

The total number of children must always be a multiple of 12.

In the original situation, we can say there were X children in one group (swings) and Y in the other (climbing frame). We know X + 2 = 2(Y - 2) and that X - 2= Y + 2. Solving these simultaneous equations reveals that X was 14 and Y was 10, making 24 children in total.

If N children swap from one group to the other then X + N = 2(Y - N) and X - N = Y + N, which leads to X = 7N and Y = 5N. This makes the total number of children 12N.

Aesthetic scrotums

Surprises abound in "The scrotum: A comparison of men's and women's aesthetic assessments", a study done by plastic surgeon Carolin Eimer in Hamburg, Germany, and two colleagues at the Medical School of Hamburg.

It begins by citing a 27-year-old psychology paper called "Gender and attractiveness biases in hiring decisions: Are more experienced managers less biased?"

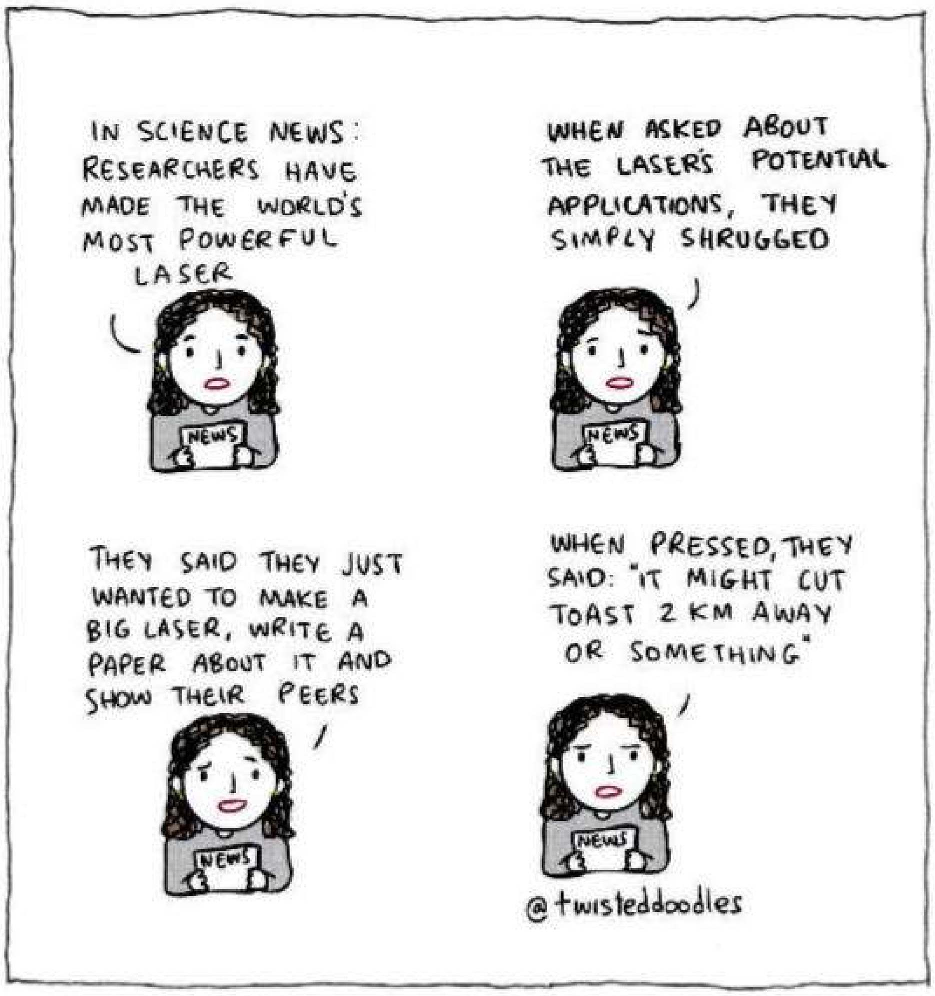
It avers that "studies have yet to investigate aesthetic preferences as regards the scrotum".

It states several hypotheses and remarks about one of them: "Our sixth hypothesis suggested that men would rate their scrotum significantly more positively than women their vulva... However, we were unable to identify any significant difference in ratings by gender." It presents four data tables, the last of which bears this label: "Descriptive statistics for evaluation of each scrotum and each variation, by gender, in order of perceived attractiveness of the scrotums."

It includes exactly 36 close-up, black-and-white photographs of scrotums. It also includes this plaintive, 18-word conclusion: "Ultimately, it was barely possible to identify a 'beautiful' scrotum; we must instead speak of the least ugly."

Feedback won't deprive you, treasured reader, of the opportunity to experience firsthand the other surprises prepared for you by the three creators of "The scrotum".

Twisteddoodles *for New Scientist*


IN SCIENCE NEWS: RESEARCHERS HAVE MADE THE WORLD'S MOST POWERFUL LASER
NEWS
WHEN ASKED ABOUT THE LASER'S POTENTIAL APPLICATIONS, THEY SIMPLY SHRUGGED
NEWS
THEY SAID THEY JUST WANTED TO MAKE A BIG LASER, WRITE A PAPER ABOUT IT AND SHOW THEIR PEERS
NEWS
WHEN PRESSED, THEY SAID: "IT MIGHT CUT TOAST 2 KM AWAY OR SOMETHING"
NEWS
@twisteddoodles

Got a story for Feedback?

Send it to feedback@newscientist.com or
New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

Workaday experiment

What would two scientists discover by adding some small requirements to a person's work day, then later removing one requirement?

Here are the added requirements. (1) Eat nothing overnight or in the morning before coming to work. (2) Arrive at work more than an hour earlier than usual. (3) Prior to beginning the day's work, sit quietly for 15 minutes while technicians prepare to wire you up so they can record electrical activity from your brain and heart as you do some mental tasks (in which you look at visual images and decide whether to press a button).

Then, (4) fill out a 24-item survey designed to get at the question "How do you feel right now?" Then, (5) let the technicians extract a small amount of your blood. Then, (6) eat a special breakfast. Then, (7) do your "standard 7-h working day with 10-min breaks every 50 min". After the day's work is done, (8) let technicians wire you up again, to record some more brain and heart data. Then, (9) eat a special dinner.

A week later, each person did all those things again – with one exception. Instead of working for 7 hours, the participants treated the 7 hours as "free time" during which "strenuous physical and cognitive activity were forbidden".

Marius Brazaitis and Andrius Satas, both at the Lithuanian Sports University, did this experiment, then wrote it up in the *International Journal of Psychophysiology*. They report that the day filled with work and short breaks "induced mental fatigue and impaired cognitive function". But the day of continuous free time did not. That difference, they say, taught them a lesson: "regular short breaks during the working day do not protect against exhaustion caused by mental work".

Me-in-a-museum

Have you discovered, in a museum, some non-human exhibit that looks startlingly like you? A taxidermied bird, perhaps, or a rock sample, or a historic old shoe? A waxwork flower? A fossil? Maybe a painted or sculpted depiction of some animal, vegetable, microbe or molecule?

If so, we would love to hear about it. Please provide a description of the item in no more than 25 words, along with a photograph. Specify which museum has "you" on display. We will artfully select some of the very most utterly display-worthy offerings, and tell about them here in Feedback. Send your entry to "Me-in-a-Museum", c/o Feedback. But please take care: this new collection is about NON-HUMAN items that resemble people.

And if you know of existing, well-curated collections of non-human/human doppelgangery, please point us to them. Two we know about already. One is the Hall of Curious Stones in Chichibu, Japan, which houses many rocks resembling human heads (one pictured below).

The other is also in Japan, which has a small history of rocks and rocklike objects that resemble humans or other species. The smallest collection – well, smallest if you consider the size of the items, but largest if you consider the quantity of items – was gathered by palaeontologist Chonosuke Okamura. He took microscopic photos of thousands of mini-creatures: fossilised mini-fishes, mini-reptiles, mini-mammals, mini-plants and even mini-dragons, each less than a centimetre in length. He published them in a series of books and was awarded the 1996 Ig Nobel prize for biodiversity for "discovering the fossils of dinosaurs, horses, dragons, princesses, and more than 1000 other extinct 'mini-species'".

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